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VOL. XXVI.

1903-1904.

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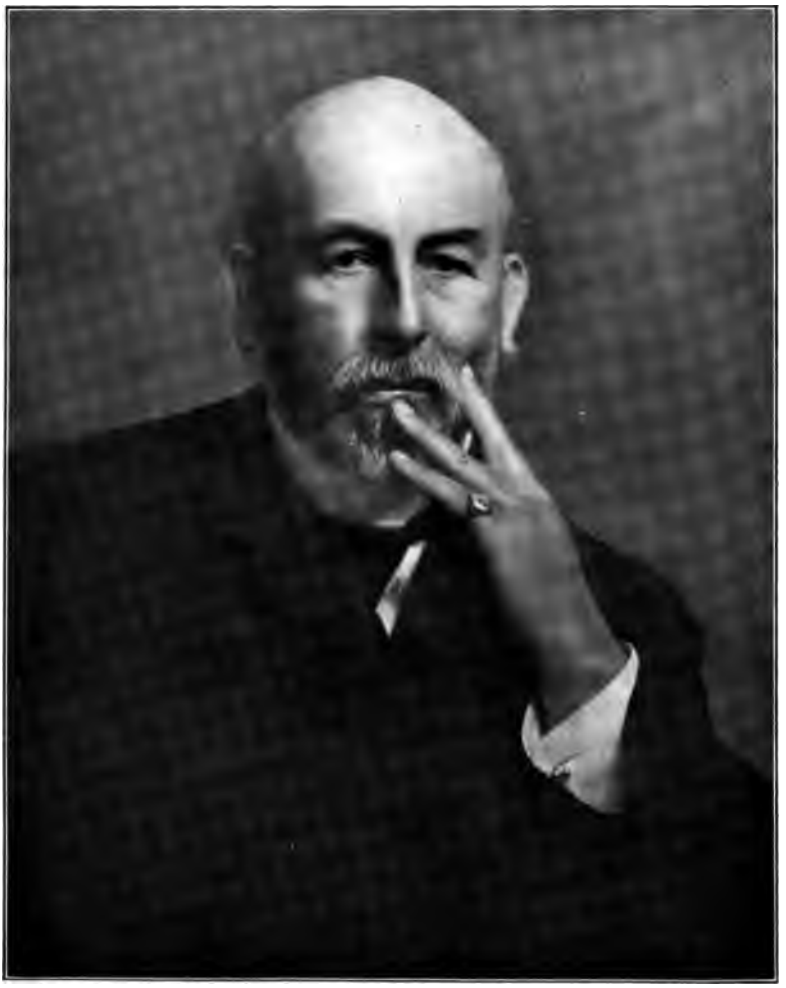

JOHN ALFRED LONGDEN,

PRESIDENT OF THE INSTITUTION OF MINING ENGINEERS, 1898-1899.

TRANSACTIONS

OF

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OF

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VOL. XXVI.—1903-1904.

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Assoc.M.Inst.M.E.

Each Associate Member shall be a person connected with or interested in mining, metallurgy, or engineering, and not practising as a mining, metallurgical, or mechanical engineer, or some other branch of engineering.

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Assoc.Inst.M.E.

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Compound winding-engines.
Compressed-air as a motive-power.
Corrosive action of mine-water on pumps, etc.
Descriptions of coal-fields.
Diamond-mining.
Distillation of oil-shales.
Drift and placer-mining.
Duration of coal-fields of the world.
Electric mining lamps.
Electricity and its applications in mines.
Electro-metallurgy of copper, etc.
Engine-counters and speed-recorders.
Explosions in mines.
Explosives used in mines.
Faults and veins.
Fuels and fluxes.
Gas-producers, and gaseous fuel and illuminants.
Gas, oil and petroleum engines.
Geology and mineralogy.
Gold-recovery plant and processes.
Graphite: its mining and treatment.
Haulage in mines.
Industrial assurance.
Inspection of mines.
Laws of mining and other concessions.
Lead-smelting.
Light railways.
Lubricating value of grease and oils.
Lubrication of trams and tubs.
Maintenance of canals in mining districts.
Manufacture of fuel-briquettes.
Mechanical preparation of ores and minerals.
Mechanical ventilation of mines, and efficiency of the various classes of ventilators.
Metallurgy of gold, silver, iron, copper, lead, etc.
Mining and uses of arsenic, asbestos, bauxite, mercury, etc.
Natural gas, conveyance and uses.
Occurrence of mineral ores, etc.
Ore-sampling machines.
Petroleum-deposits.
Preservation of timber.
Prevention of over-winding.
Pumping machinery.
Pyrometers and their application.
Quarries and methods of quarrying.
Rock-drills.
Safety-lamps.
Salt-mining, etc.
Screening, sorting and cleaning of coal.
Shipping and discharge of coal-cargoes.
Sinking, coffering and tubbing of shafts.
Sleepers of cast-iron, steel and wood.
Spontaneous ignition of coal and coal-seams.
Stamp-milling.
Steam-condensation arrangements.
Steam-power plants.
Submarine coal-mining.
Subsidences caused by mining-operations.
Surface-arrangements at mines.
Surveying.
Tin-mining.
Transport on roads.
Tunnelling, methods and appliances.
Utilization of dust and refuse coal.
Utilization of sulphureous gases resulting from metallurgical processes.
Ventilation of coal-cargoes.
Water as a motive-power in mines.
Water-tube boilers.
Watering coal-dust.
Water-incrustations in boilers, pumps, etc.
Winding arrangements at mines.
Winning and working of mines at great depths.

For selected papers, the Council may award prizes. In making awards, no distinction is made between communications received from members of the Institution or others.

TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 1ST, 1903.

SIR LINDSAY WOOD, BART., RETIRING PRESIDENT, IN THE CHAIR.

DEATH OF EARL RAVENSWORTH.

The RETIRING PRESIDENT (Sir Lindsay Wood, Bart.) said that Earl Ravensworth was elected a patron of the Institute in 1877, and had therefore held that office for more than a quarter of a century. He sat in the House of Commons as Lord Eslington from 1852 to 1878, and during that time he had rendered great assistance to the Coal-trade during the discussion and passing through the House of the many important Bills which affected that trade. His opinions on such matters were always respected by both sides of the House, whichever government was in power and it was largely due to his assistance and influence that the Institute obtained from H.M. the late Queen Victoria, the honour of a Royal Charter in 1876.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on July 18th and that day, and of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1903-1904.

The RETIRING PRESIDENT appointed Messrs. George May, John Simpson, W. B. Wilson, junr. and J. Kirsopp, junr., as scrutineers of the balloting-papers for the election of officers for the year 1903-1904.

The SCRUTINEERS afterwards reported the result of the ballot, as follows:—

PRESIDENT:

Mr. W. O. WOOD.

VICE-PRESIDENTS:

Mr. R. D. BAIN.	Mr. W. C. BLACKETT.	Mr. W. LOGAN.
Mr. C. BERKLEY.	Mr. T. E. FORSTER.	Mr. J. H. MERIVALE.

COUNCILLORS:

Mr. R. S. ANDERSON.	Mr. H. LAWRENCE.	Mr. M. W. PARRINGTON.
Mr. B. DODD.	Mr. C. C. LEACH.	Mr. J. SHIEL.
Mr. M. H. DOUGLAS.	Prof. H. LOUIS.	Mr. F. R. SIMPSON.
Mr. T. Y. GREENER.	Mr. J. MORISON.	Mr. J. SIMPSON.
Mr. J. K. GUTHRIE.	Mr. J. H. NICHOLSON.	Mr. R. F. SPENCE.
Mr. T. E. JOBLING.	Mr. H. PALMER.	Mr. R. L. WEEKS.

The CHAIRMAN (Sir Lindsay Wood, Bart.) moved, and Mr. J. C. B. HENDY seconded, a vote of thanks to the scrutineers for their services, and it was cordially approved.

Mr. THOMAS DOUGLAS (Darlington) moved a vote of thanks to the Retiring President, Vice-Presidents and Councillors, and to the representatives of the Institute on the Council of The Institution of Mining Engineers for their services during the past year. The President (Sir Lindsay Wood, Bart.) had rendered valuable services to the Institute during his term of office. The Jubilee celebrations of the Institute had imposed upon the President very onerous duties and responsibilities, and he had carried them out with the utmost satisfaction to the members.

Mr. A. L. STEAVENSON (Durham), in seconding the vote of thanks, referred to the advance which had been made in mining science during the last 50 years. The objects, which the father of their Retiring President—the late Mr. Nicholas Wood—in conjunction with the other gentlemen who assisted him in found-

ing the Institute had in view, had been very fully carried out, and he hoped that the next 50 years might see an equal advance.

The vote of thanks was cordially adopted.

The RETIRING PRESIDENT, in acknowledging the vote of thanks, said that he felt sure the Institute was doing good work and was carrying out the wishes of its founders.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1902-1903.

The Jubilee of the Institute was celebrated in the Wood Memorial Hall on September 16th, 1902. The members were received by the President, Sir Lindsay Wood, Bart., who delivered an address; and at his invitation, a conversazione was held in the Museum of the Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne, by permission of that Society. A large number of members and representatives from other societies attended.

The Institution of Mining Engineers held their Annual General Meeting in Newcastle-upon-Tyne on September 17th, 18th and 19th, in conjunction with the Jubilee Meeting of this Institute. The large number of members present necessitated the congress being held in two sections. The best thanks of the members are due to the committee who made the arrangements, to the owners of collieries and works open for inspection, and to all those who by their services contributed to the holding of that successful meeting.

The following table shows the progress of the membership during the past few years:—

Year ending August 1st.	1893.	1898.	1903.
Honorary Members	25	30	26
Members	565	859	921
Associate Members	47	113	112
Associates	47	103	161
Students	34	51	69
Subscribers	22	22	23
Totals	740	1,180	1,312

The members are to be congratulated upon the increase in the membership of the Institute:—155 members of all classes

have been added to the register during the past year, and after allowing for losses by deaths and resignations, there is a net increase of 74 members.

The Library has been maintained in an efficient condition during the year; the additions by donation, exchange and purchase, include 449 bound volumes, 123 pamphlets, reports, etc.; and the Library now contains about 9,392 volumes and 2,763 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them readily available for reference.

Members would render useful service to the profession, by presentations of books, reports, plans, etc., to the Institute, to be preserved in the Library and available for reference.

The courses of lectures for colliery-engineers, engine-wrights and apprentice-mechanics have been continued at the Durham College of Science. The lectures are delivered on Saturday afternoons, and the three years' course embraces the following subjects:—

1903-1904. Michaelmas Term, (1) Mensuration, and (2) the Chemistry of Fuel. Epiphany Term, (3) Strength of Materials, and (4) Experimental Mechanics.

1904-1905. Michaelmas Term, (5) Theoretical Electricity, and (6) Electrical Engineering. Epiphany Term, (7) Steam-engines and Boilers, and (8) Haulage and Winding.

1905-1906. Michaelmas Term, (9) Transmission of Power, and (10) Pumping and Ventilation. Epiphany Term, (11) Metallurgy of Iron and Steel, and (12) Mining Machinery (mainly machinery used underground).

Several colliery-owners have paid the fees (£1 10s. 0d. per annum) and railway expenses of pupils attending the classes from their collieries. During the past year, the lectures of the Michaelmas Term on the Transmission of Power were attended by 61 students, and Pumping and Ventilation by 65 students, 52 sat for examination and 39 passed; and during the Epiphany Term, the lectures on the Metallurgy of Iron and Steel were attended by 61 students, and Mining Machinery (chiefly used underground) by 59 students, 43 were examined and 28 passed. Prizes were awarded to Messrs T. H. Bolton and J. H. Thompson. Certificates have been awarded to the following students who have completed the three years' course:—Messrs. T. H. Bolton, G. T. Hughes, S. Hutchinson, H. Nicholson and R. D. Oswald.

A loyal and dutiful address was forwarded to His Majesty, King Edward the Seventh, and Her Majesty Queen Alexandra, on the occasion of Their Majesties' Coronation on August 9th, 1902.

The G. C. Greenwell bronze medal has been awarded to Mr. A. A. Atkinson (H.M. Inspector of Coal-mines, New South Wales), for his paper upon "Working Coal under the River Hunter, the Pacific Ocean and its Tidal Waters, near Newcastle, in the State of New South Wales."*

The Council have decided to publish a supplementary volume to *An Account of the Strata in Northumberland and Durham, as proved by Borings and Sinkings*, and members are desired to send copies of any unpublished sections on strata in these counties, or their section-books, to the secretary on loan. A small tracing from the 6 inches Ordnance Map, showing the position of any shaft or bore-hole, if not already fixed by previous publications, will greatly facilitate the work.

Mr. John Daglish continues to represent the Institute as a governor of the Durham College of Science, which was jointly founded in 1871 by the University of Durham and the North of England Institute of Mining and Mechanical Engineers. Mr. T. E. Forster, in conjunction with the President (Sir Lindsay Wood, Bart.), represents the Institute on the Council of the Durham College of Science.

Mr. J. H. Merivale will again represent the Institute at the Conference of the Corresponding Societies of the British Association for the Advancement of Science, to be held in Southport, commencing on September 9th, 1903. Mr. W. Cochrane represents the Institute upon the Board of Directors of the Institute and Coal Trade Chambers Company, Limited.

The representatives of the Institute upon the Council of The Institution of Mining Engineers during the past year were as follows:—Sir Lowthian Bell, Bart., Sir David Dale, Bart., Sir Lindsay Wood, Bart., and Messrs. William Armstrong, John Batey, T. W. Benson, Bennett H. Brough, A. G. Charleton, John Daglish, T. E. Forster, William Galloway, John Gerrard, Reginald Guthrie, Philip Kirkup, C. C. Leach, Henry Louis, George May, John Morison, M. W. Parrington, R. A. S. Redmayne, A. R. Sawyer, J. B. Simpson, John G. Weeks and W. O. Wood.

An exchange of *Transactions* has been arranged, during the year, with the Cuerpo de Ingenieros de Minas del Perú.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 622.

Prizes of books have been awarded to the writers of the following papers communicated to the members during the year 1901-1902:—

"A Method of Socketing a Winding-rope, and its Attachment to a Cage without the Use of Ordinary Chains." By Mr. W. C. Blackett, M.I.M.E.

"Mechanical Undercutting in Cape Colony." By Mr. John Colley, M.I.M.E.

"Electric Pumping-plant at South Durham Collieries." By Mr. Fenwick Darling, M.I.M.E.

"Some Silver-bearing Veins of Mexico." By Mr. Edward Halse, M.I.M.E

"Apparatus for Closing the Top of the Upcast-shaft at Woodhorn Colliery." By Mr. C. Liddell, Stud.I.M.E.

"A Visit to the Simplon Tunnel: the Works and Workmen." By Dr. Thomas Oliver.

"The Carboniferous Limestone Quarries of Weardale." By Mr. A. L. Steavenson, M.I.M.E.

"Auriferous Gravels and Hydraulic Mining." By Mr. W. S. Welton, M.I.M.E.

"Tapping Drowned Workings at Wheatley Hill Colliery." By Mr. W. B. Wilson, jun., M.I.M.E.

The papers printed in the *Transactions* during the year are as follows:—

"Working a Thick Coal-seam in Bengal, India." By Mr. Thomas Adamson, M.I.M.E.

"The Use of Carboniferous Plants as Zonal Indices." By Mr. E. A. Newell Arber.

"The Gases enclosed in Coal and Coal-dust." By Prof. P. Phillips Bedson, Hon. M.I.M.E.

"Improved Offtake-socket for Coupling and Uncoupling Hauling-ropes." By Mr. W. C. Blackett, M.I.M.E.

"Description of the Lead-ore Washing-plant at the Greenside Mines, Patterdale." By Mr. Wm. H. Borlase, M.I.M.E.

"Granite-quarrying, Sett-making and Crushing; and the Manufacture of Concrete-flags and Granitic Tiles." By Mr. Geo. H. Bragg.

"The Gases enclosed in Coal." By Dr. Broockmann.

"The Gypsum of the Eden Valley." By Mr. D. Burns, M.I.M.E.

"Sinking by the Freezing Method at Washington, County Durham." By Mr. Mark Ford, M.I.M.E.

"The Crumlin Meteorite." By Principal H. Palin Gurney, Hon. M.I.M.E.

"Some Silver-bearing Veins of Mexico." By Mr. Edward Halse, M.I.M.E.

"Air-compression by Water-power: The Installation at the Belmont Gold-mine." By Mr. D. G. Kerr, M.I.M.E.

"Ambulance-instruction at Mines." By Mr. William Leck, M.I.M.E.

"The Occurrence of Gold in Great Britain and Ireland." By Mr. J. Malcolm Maclaren, M.I.M.E.

"Report of the Delegate to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Belfast, 1902." By Mr. J. H. Merivale, M.I.M.E.

"Some of the Considerations affecting the Choice of Pumping Machinery." By Messrs. A. H. Meysey-Thompson, M.I.M.E., and H. Lupton.

"Treatment of Low-grade Copper-ores." By Dr. Edward Dyer Peters.
"A Measuring-tape, and its Use in Mine-surveying." By Mr. S. J. Pollitzer, M.I.M.E.
"The Underlay-table." By Mr. S. J. Pollitzer, M.I.M.E.
"The Geology of the English Lake District." By Mr. J. Postlethwaite.
"The Utilization of Exhaust-steam by the Combined Application of Steam-accumulators and Condensing Turbines." By Prof. A. Rateau, M.I.M.E.
"The Max Electric Mining Lamp." By Mr. E. Roubier.
"The Valuation of Gas-coals." By Mr. James Stewart.
"Hæmatite-deposits and Hæmatite-mining in West Cumberland." By Mr. W. E. Walker, M.I.M.E.
"Address." By Sir Lindsay Wood, Bart., M.I.M.E.

Excursions have been made to the Newbottle Collieries of the Lambton Collieries, Limited, and to mines and works in the neighbourhood of Cleator Moor, Keswick, Whitehaven and Workington, and the thanks of the members have been accorded to the owners of these mines and works.

The Committee appointed to "investigate and report on labour-saving machines and tools used in cutting and boring coal and rock" will shortly issue their first report.

The Coal-mines Regulation Act (1887) Amendment Act, which has recently received Royal assent, will enable the holder of a diploma in scientific and mining training, after a course of study of at least two years, at any University, University College, Mining School or other Educational Institution, to be approved of by a Secretary of State, or of a degree of any University to be so approved of, which includes scientific and mining subjects, after having had practical experience in a mine for at least three years, to sit for a Certificate of Competency as Manager or Under-manager under the Coal-mines Regulation Act, 1887.

The RETIRING PRESIDENT (Sir Lindsay Wood, Bart.), in moving the adoption of the report of the Council, hoped that the Institute would for many years be able to present such satisfactory reports.

Mr. THOMAS DOUGLAS seconded the resolution, which was unanimously agreed to.

The Report of the Finance Committee was read as follows:—

REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1903, duly audited.

The total receipts were £2,888 5s. 2d. Of this amount, £69 18s. was paid for life-compositions in lieu of annual subscriptions, and £78 10s. as subscriptions in advance, leaving £2,739 17s. 2d. as the ordinary income for the year, compared with £2,675 16s. 6d. in the previous year.

The total expenditure was £3,726 4s. 4d., as compared with £2,443 9s. 4d. for the previous year. The principal item in this increase is the sum of £1,006 3s. paid on account of the alterations to the Lecture Theatre; £118 2s. 11d. was expended in connection with the Jubilee Meeting, and £42 4s. on behalf of the Coal-cutting Committee; medals costing £67 8s. 4d. have been purchased out of the Greenwell Prize Fund; and the contributions to The Institution of Mining Engineers show an increase of £104 5s. 9d., due to the larger membership. From the figures shown above, it will be seen that the total expenditure during the year exceeded the income by £837 19s. 2d., and deducting this amount from the balance in hand at the beginning of the year, there is a sum of £169 7s. 10d. to carry forward. There still remains about £160 to be paid in connection with the alterations and furnishing of the Lecture Theatre, and this will be met out of the revenue for the ensuing year.

The names of 38 persons have been struck off the membership-list, in consequence of non-payment of subscriptions. The amount of subscriptions written off was £160 14s., of which £81 8s. was for sums due during the year ending June 30th, 1903, and £79 6s. for amounts which had fallen due in previous years. The recovery of these amounts has been placed in the hands of the solicitors, and the amounts obtained by them will be placed to the credit of the account in future years.

JOHN G. WEEKS.

August 1st, 1903.

The RETIRING PRESIDENT (Sir Lindsay Wood, Bart.) moved the adoption of the report of the Finance Committee.

Mr. J. G. WEEKS seconded the resolution, which was unanimously adopted.

General Statement, June 30th, 1903.

Liabilities.

	£	s.	d.	£	s.	d.
Subscriptions paid in advance during the current year	78	10	0			
Ditto. in previous year	4	4	0			
	82	14	0			
The Institution of Mining Engineers ...	30	3	11			
Printing	24	8	8			
				137	6	7
The George Clementson Greenwell Prize Fund £100 0 0						
Less—Paid for Medals ... 67 8 4						
	32	11	8			
Mr. Clarence R. Claghorn: Prize for Essay	10	0	0			
				42	11	8
Capital				11,298	19	1
				£11,478	17	4

We, having examined the above account with the books, vouchers and securities relating thereto, certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other Publications as valued by your Officials.

JOHN G. BENSON AND SONS,
Chartered Accountants.

Newcastle-upon-Tyne,
August 1st, 1903.

Assets.

	£	s.	d.	£	s.	d.
Balance of Account at Bankers	103	5	7			
,, in Treasurer's hands	61	9	6			
Author's Excerpts	4	12	9			
				169	7	10
Arrears of Subscription				306	4	0
179 Shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...	4,100	0	0			
Investment with the Institute and Coal-trade Chambers Company, Limited (Mortgage) ...	1,400	0	0			
				5,500	0	0
(Of the above amount, £1,484 is due to Life Subscriptions Account.)						
Value of *Transactions* and other Publications, as per Stock Account				353	5	6
Books, Pictures, Maps, Furniture and Fittings				5,150	0	0
				£11,478	17	4

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

June 30th, 1902.	£ s. d.	£ s. d.
To Balance at Bankers	949 17 6	
„ „ in Treasurer's hands	56 8 6	
„ Outstanding Accounts due from Authors for Excerpts	1 1 0	
		1,007 7 0
June 30th, 1903.		
To Dividend of 7½ per cent. on 179 Shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the Year ending June 30th, 1903 ... ... £268 10 0		
Less—Repaid on purchased Shares ... 9 0 0		
	259 10 0	
„ Interest on Mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited	49 0 0	
		308 10 0
To Sale of *Transactions*		18 9 2
To SUBSCRIPTIONS FOR YEAR 1902-1903 AS FOLLOWS :—		
726 Members ... ... @ £2 2s.	1,524 12 0	
83 Associate Members ... ... @ £2 2s.	174 6 0	
105 Associates ... ... @ £1 5s.	131 5 0	
59 Students ... ... @ £1 5s.	73 15 0	
77 New Members ... ... @ £2 2s.	161 14 0	
3 New Members (not yet elected) ... @ £2 2s.	6 6 0	
16 New Associate Members ... ... @ £2 2s.	33 12 0	
30 New Associates ... ... @ £1 5s.	37 10 0	
28 New Students ... ... @ £1 5s.	35 0 0	
	2,178 0 0	
23 Subscribing Firms	96 12 0	
	2,274 12 0	
To LIFE COMPOSITIONS :—		
1 Member £24 0 0		
2 New Members 45 18 0		
	69 18 0	
	2,344 10 0	
Less—Subscriptions for Current Year paid in advance at the end of Last Year	106 12 0	
	2,237 18 0	
Add—Arrears received	244 18 0	
	2,482 16 0	
Add—Subscriptions paid in advance during the Current Year	78 10 0	
		2,561 6 0
		£3,895 12 2

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. CR.

JUNE 30TH, 1903.

June 30th, 1903.	£	s.	d.	£	s.	d.
By Annual Report	35	6	9			
„ Banker's Charges	21	9	10			
„ British Association for the Advancement of Science: Expenses of Delegate	8	6	7			
„ Circulars, etc.	48	8	5			
„ Cleaning Wood Memorial Hall, Offices, etc.	37	19	6			
„ Coal-cutting Committee	42	4	0			
„ Electric Light and Gas	45	15	10			
„ Expenses of Jubilee Meeting, etc.	118	2	11			
„ Fire Insurance	12	13	10			
„ Fuel	18	12	0			
„ Furniture and Repairs	48	5	0			
„ George Clementson Greenwell Prize Fund: Medals	67	8	4			
„ Incidental Expenses	8	12	5			
„ Lecture Theatre: Alterations	1,006	3	0			
„ Library—Binding £67 12 9						
„ „ Books 37 16 10						
	105	9	7			
„ Petty Cash	3	9	10			
„ Postages—Circulars £35 9 0						
„ „ Correspondence 19 15 8						
„ „ Publications 24 2 9						
	79	7	5			
„ Prizes for Papers	22	1	0			
„ Rates and Taxes	6	8	3			
„ Rent of Offices	24	7	10			
„ Reporting of General Meetings	12	12	0			
„ Salaries, Wages, Auditing, etc.	487	17	4			
„ Stationery, etc.	24	10	10			
„ Subject-Matter Index	84	8	5			
„ Telephone Rent	2	17	0			
„ Translations of Papers	2	15	6			
„ Travelling Expenses	1	3	0			
„ Typewriter	21	7	0			
„ Water Rate	4	12	4			
				2,402	15	9
By The Institution of Mining Engineers	1,328	12	10			
Less—Amount paid by Authors for Excerpts	5	4	3			
				1,323	8	7
				3,726	4	4
By Balance at Bankers	103	5	7			
„ „ in Treasurer's hands	61	9	6			
„ Outstanding Accounts due from Authors for Excerpts	4	12	9			
				169	7	10
				£3,895	12	2

We, having examined the above account with the books and vouchers relating thereto, certify that, in our opinion, it is correct.

JOHN G. BENSON AND SONS.
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne, August 1st, 1903.

DR. THE TREASURER IN ACCOUNT

		£ s. d.	£ s. d.
To 893 Members.			
48 of whom have paid Life Compositions.			
845			
6 not included in printed list.			
851	@ £2 2s.		1,787 2 0
1 Member paid Life Composition			24 0 0
To 109 Associate Members.			
8 of whom have paid Life Compositions.			
101			
1 of whom has paid as a New Member.			
100	@ £2 2s.		210 0 0
To 122 Associates,			
3 of whom have paid as New Members.			
119			
2 not included in printed list.			
121			
1 of whom has paid Life Composition.			
120	@ £1 5s.		150 0 0
To 66 Students	@ £1 5s.		82 10 0
To 23 Subscribing Firms			96 12 0
To 77 New Members	@ £2 2s.		161 14 0
To 2 New Members who have paid Life Compositions			45 18 0
To 3 New Members, not yet elected			6 6 0
82			
To 16 New Associate Members	@ £2 2s.		33 12 0
To 30 New Associates	@ £1 5s.		37 10 0
To 28 New Students	@ £1 5s.		35 0 0
			2,670 4 0
To Arrears, as per Balance Sheet 1901-1902		319 3 0	
Add—Arrears considered irrecoverable, but since paid...		66 19 0	
			386 2 0
			3,056 6 0
To Subscriptions paid in advance			78 10 0
			£3,134 16 0

WITH SUBSCRIPTIONS, 1902-1903. CR.

			PAID. £ s. d.	UNPAID. £ s. d.	STRUCK OFF LIST. £ s. d.
By 726	Members, paid	@ £2 2s.	1,524 12 0	.....	.....
By 97	„ unpaid ...	@ £2 2s.	.....	203 14 0	.....
By 2	„ dead	@ £2 2s.	.....	.....	4 4 0
By 26	„ struck off list	@ £2 2s.	.....	.....	54 12 0
851					
By 1	Member, paid Life Composition		24 0 0	.....	.....
By 83	Associate Members, paid	@ £2 2s.	174 6 0	.....	.....
By 11	„ „ unpaid	@ £2 2s.	.....	23 2 0	.....
By 6	„ „ struck off list ...		.....	.....	12 12
100					
By 105	Associates, paid	@ £1 5s.	131 5 0	.....	.....
By 8	„ unpaid ...	@ £1 5s.	.....	10 0 0	.....
By 7	„ struck off list	@ £1 5s.	.....	.....	8 15
120					
By 59	Students, paid	@ £1 5s.	73 15 0	.....	.....
By 6	„ unpaid ...	@ £1 5s.	.....	7 10 0	.....
By 1	„ struck off list	@ £1 5s.	.....	.....	1 5 0
66					
By 23	Subscribing Firms, paid		96 12 0	.....	.....
By 77	New Members, paid ...	@ £2 2s.	161 14 0	.....	.....
By 2	New Members, paid Life Compositions		45 18 0	.....	.....
By 3	New Members, not yet elected, paid	@ £2 2s.	6 6 0	.....	.....
82					
By 16	New Associate Members, paid	@ £2 2s.	33 12 0	.....	.....
By 30	New Associates, paid ...	@ £1 5s.	37 10 0	.....	.....
By 28	New Students, paid ...	@ £1 5s.	35 0 0	.....	.....
			2,344 10 0	244 6 0	81 8 0
By Arrears			214 18 0	61 18 0	79 6 0
			2,589 8 0		
By Subscriptions paid in advance			78 10 0	.....	.....
			2,667 18 0	306 4 0	160 14 0
					306 4 0
					2,667 18 0
					£3,134 16 0

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1903-1904.

The RETIRING PRESIDENT (Sir Lindsay Wood, Bart.) moved, and Mr. J. K. GUTHRIE seconded a resolution, that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers for the year 1903-1904:—

Mr. WILLIAM ARMSTRONG.	Mr. REGINALD GUTHRIE.	Mr. JOHN MORISON.
Mr. JOHN BATEY.	Mr. T. E. JOBLING.	Mr. HENRY PALMER.
Mr. T. W. BENSON.	Mr. PHILIP KIRKUP.	Prof. R. A. S. REDMAYNE.
Mr. BENNETT H. BROUGH.	Mr. C. C. LEACH.	Mr. H. RICHARDSON.
Mr. W. FORSTER BROWN.	Mr. WILLIAM LOGAN.	Mr. J. B. SIMPSON.
Mr. J. S. BURROWS.	Prof. HENRY LOUIS.	Mr. A. L. STEAVENSON.
Mr. JOHN DAGLISH.	Mr. J. H. MERIVALE.	Mr. JOHN G. WEEKS.
Mr. T. E. FORSTER.	Mr. C. A. MORRING.	Mr. GARDNER F. WILLIAMS.

The resolution was agreed to.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. CHARLES ERNEST ALGER, Mechanical and Electrical Engineer, 160, Dock Street, Newport, Monmouthshire.

Mr. GILBERT FREDERICK ARCHER, Mechanical Engineer and Draughtsman, 11, Regent Terrace, Gateshead-upon-Tyne.

Mr. WILLIAM BLACK, Mining Engineer, 39, Crossfield Road, Cleator Moor, Cumberland.

Mr. LOUIS P. BOWLER, Mine-manager and Engineer, Axim, Gold Coast, West Africa.

Mr. EDWIN HENRY GREEN, Mechanical Engineer, P.O. Box 1978, Johannesburg, Transvaal.

Mr. RICHARD HARTLEY, Mining Engineer, 46, Lowther Street, Whitehaven.

Mr. CHARLES EDWARD HOPE, Engineer, Vancouver, British Columbia.

Mr. JOSEPH MUSGRAVE KEARNEY, Mining Engineer, 53, Market Place, Whitehaven.

Mr. ELIAH GEORGE PAMPLIN, Engineer, Cherryhinton, Cambridge.

Mr. ROBERT WILLIAM PRINGLE, Mining Engineer, c/o the Rev. J. C. Pringle, All Saints' Rectory, Poplar, London, E.

Mr. THOMAS SHEWAN, Colliery Manager, Saint Hilda Colliery, South Shields.

Mr. EDMUND BESSELL WHALLEY, H.M. Inspector of Mines, Edinburgh.

Mr. THOMAS HUGHES WILLIAMS, Colliery Manager, Tynedale Colliery, Hexham.

Mr. THOMAS P. YEOMAN, Mining Engineer, Government Collieries, Warora, Central Provinces, India.

ASSOCIATE MEMBERS—

Mr. SCOTT GUNN, 18, John Street, Sunderland.

Mr. EUGENE HAANEL, Department of the Interior, Ottawa, Ontario, Canada.

Mr. SAMUEL THOMPSON, P.O. Box 15, Greytown, Natal, South Africa.

STUDENTS—

Mr. ALBERT EDWARD DOUGLAS, Mining Student, Usworth Hall, County Durham.

Mr. ALFRED POTTS, Mining Student, Esh Colliery Office, near Durham.

DISCUSSION OF MR. H. D. D. BARMAN'S PAPER ON "THE RIEDLER PUMP."*

Mr. A. L. STEAVENSON (Durham) said that the Riedler pump was a well-designed machine, and the only difficulty that he saw in connection with it was with reference to the conditions under which it should be used. Under all circumstances he was strongly opposed to the introduction of steam underground, and there was now no necessity for this, in view of the other methods of conveying power by means of electricity, compressed air and endless ropes, though, no doubt there might be exceptional circumstances under which boilers, cased in brickwork, might be used. He thought that it would be an advantage for engineers to distinguish between the terms plungers and rams:—He thought that "ram" should be used in the case of a solid body of metal going into a cylinder, and "plunger" for a double-acting piston. He asked whether Mr. Barman could give the useful effect of each pump described in his paper, that is:—How did the work in the water lifted compare with the power of the engine? It was stated that the volume of the water was in one instance somewhat more than the displacement of the pump. This was by no means unusual: some years ago he tested an ordinary bucket-pump, and found that the water brought to the surface exceeded the swept-volume. This might be accounted for by the fact that when the end of the stroke was reached, the water owing to its *vis viva* continued to flow, if the pumps were kept in good order. In a seam, where the lift did not exceed 150 feet, he preferred especially if working with electricity, to to use a centrifugal pump from which the flow was continuous. About 30 to 60 feet used to be the limit of height with a centrifugal pump, but, by modern improvements, this was greatly

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 238.

exceeded. He first saw them when, as a boy, he visited the Great Exhibition of 1851. He would be pleased to show any of the members one of these high-lift centrifugal pumps working at a mine with which he was connected. He agreed with the writer of the paper that where steam-engines were used underground, it was necessary to provide some means of destroying the steam. So long ago as 1864 he had adapted a cistern for this purpose. The exhaust-steam from the engine entered the cistern, having a perforated cover, and the water delivered on the top passed through and condensed all the steam.

Mr. H. D. D. Barman (Airdrie, N.B.) said that the paper was written by himself as a mechanical engineer, and the question as to whether air, electricity, or ropes should be employed in preference to steam underground was one which must be decided by the mining engineer. The Riedler pump, however, could be driven by any of these methods. He did not quite understand Mr. Steavenson with reference to the difference between the terms "plunger" and "ram"; to his own mind the terms were interchangeable. The ram he should say was the moving part that practically filled the barrel, and the plunger was one which occupied a very small space in the pump-barrel. In the first pump that he designed, he left only ¼ inch of clearance between the sides of the barrel and the plunger, and this caused considerable trouble; and his chief object now in designing a new pump was to use a small diameter of plunger or ram, in comparison with the diameter of the barrel. Some engineers tried to get all the water into the barrel and to sweep it all out at the next stroke, but this gave rise to high velocity, and high pressure where corners had to be turned, and often resulted in a burst.

At Niddrie colliery, near Portobello, the difference between the pump-diagrams and the steam-power diagrams was 9·2 per cent. Prof. John Goodman had recently read a paper* in which he shewed definitely with accurate measurements of the water pumped and the swept volume of the pumps that there was at certain speeds a very big plus-efficiency with steam-pumps; and further, he actually took out the suction-valves and delivered water without using a suction-valve. The efficiency of a series-

* *Proceedings of the Institution of Mechanical Engineers*, 1903, vol. i., page 123.

centrifugal pump was about 60 per cent., as compared with the 92 per cent. of the Riedler pump.

Mr. J. G. Weeks (Bedlington) endorsed the advice of Mr. Steavenson with regard to keeping steam out of the mine if possible, and his own experience was such that he would go to considerable expense to avoid taking steam underground. If they could derive power by means of works on the surface and convey it underground through the instrumentality of ropes, compressed air, electricity or water-pressure rather than steam it was desirable, from a financial point of view, to do so. He believed that the Riedler was an excellent pump under certain conditions, but what they required to know was the special conditions under which it could be applied to get the greatest benefit from it. He understood one of the chief advantages claimed for it was that it had mechanically controlled valves, which allowed a much higher speed to be obtained with a smaller plant, than those engines and pumps which depend upon atmospheric pressure for operating the valves. He also understood in the case of the Riedler pump that it was necessary that the plunger should be placed below the level of the water to be pumped, as if by any means, the plunger made a false stroke, owing to the water not passing quickly enough to it, then there was a great risk of considerable damage ensuing: this liability somewhat limited its general application unless a small lifting set, to pump into a cistern situated at a higher level than the plunger was also attached to the engine, and any failure to keep the cistern supplied with water would be equally disastrous.

Mr. J. C. B. Hendy (Etherley) asked whether there had been any case where the Riedler pump had been successfully employed in pumping against a head of 700 or 800 feet. With a large head of water, mechanically speaking, the principle of high-speed pumping was wrong. As the power was increased against the machine, they ought to increase the capacity of the machine and decrease the speed. He could understand a high-speed pump working successfully up to 150 or 200 feet or even more, but he could not imagine it working at a high speed against such heads of water as they had to deal with in the North of England. Had the Riedler pump been successfully employed against a head of, say, 1,500 feet, and what was the efficiency under such circumstances?

Mr. H. D. D. BARMAN, replied that the Riedler pump would draw 24 feet above the level of the water, but with such a high lift the velocity of the water through the suction-valves should be reduced. In some instances it is advantageous to use a separate condenser and an air-pump arranged so that all the water to be pumped is drawn by it from the sump, and then delivered into a tank, above the level of the main-pump. In one instance, the water was lifted 18 feet high through 100 feet of pipes. Fig. 9 (Plate X.)* showed that a pressure of 1 or 1½ pounds was given by the height of the water-tank and that the water ran direct to the suction-vessel. If there was likely to be shortage of water, the deficiency was given out by that contained in the suction-vessel. At Powell Duffryn colliery, there was a head of 1,660 feet, and the difference between the pump-diagrams and the steam-power diagrams was about 10 per cent. It was not necessary to alter the speed in accordance with the head of water, as the speed only varied with the length of stroke. The highest head was about 3,000 feet, and the piston-and-ram speed was about 500 feet per minute.

Mr. A. L. STEAVENSON said that he must not be understood to condemn the Riedler pump, but only to question the circumstances under which it was best to use it. He had long used petroleum-engines underground, in preference to steam.

The RETIRING PRESIDENT (Sir Lindsay Wood, Bart.) understood that the Riedler pump, being reciprocating, could be driven by any particular power. He agreed with other speakers that the use of steam was very undesirable down pits, but there would be no difficulty in driving the pump by electricity or compressed air.

Mr. H. D. D. BARMAN said that electricity was better than steam for driving the Riedler pump, on account of the speed of the motor.

Mr. J. K. GUTHRIE understood that the motor could be coupled direct to the pump.

Mr. H. D. D. BARMAN said that was so, but most people objected to pay the price for a low-speed motor; 1 to 4, or 1 to 6, was a very desirable gear, which allowed the use of the ordinary "market" motor and the ordinary type of Riedler pump.

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* *Trans. Inst. M.E.*, 1903, vol. xxv., page 248.

DISCUSSION OF MR. T. ADAMSON'S PAPER ON "WORKING A THICK COAL-SEAM IN BENGAL, INDIA."*

Mr. F. L. G. Simpson (Mophani Mines, Central Provinces) wrote that a few errors had occurred in the printing of his remarks:—Page 398, line 1 should read "especially where cogs"; and page 399, lines 2 and following should read "Afterwards, however, it being found possible to remove them, the 'brokens' were taken out clean by a system of modified longwall, in three or four lifts one above the other, the first being taken next the thill, followed up by packing. This packing, sent down from the surface, was used to haul out the coal by a self-acting incline."†

Mr. G. E. Harris (Margherita, Upper Assam, India) wrote that for some years he had had to deal with the working of thick seams, although of much greater thicknesses and under conditions different from those described by Mr. Adamson in his paper. To any one not acquainted with thick-coal working, the method described would no doubt appear dangerous, but the fact that accidents are very rare, and that such a large percentage of coal is got from the seam speaks well for the success of the system adopted. The general conditions lend themselves to this successful system of working, the main factor being the particularly fine roof immediately over the coal-seam—a very strong indurated stone. The coal is hard and compact, the inclination slight, and fires are seldom, if ever, known to occur. The immunity from fires allows large openings to be made, which facilitate the working of the coal. If fires were of frequent occurrence, smaller openings with thick fire-ribs would have to be left, and this would considerably reduce the percentage of coal obtained.

A few years ago, he (Mr. Harris) visited the Bengal coalfield, and had an opportunity of seeing the system then generally in vogue. What struck him most was the very large size that the roadways were made in driving out, and the very small

* *Trans. Inst. M.E.*, 1903, vol. xxv., pages 10, 192 and 396.

† *Ibid.*, 1903, vol. xxv.

pillars that were left. This no doubt enabled a very big percentage of the seam to be extracted in the first drivings, but he was curious to learn what the result would be when the time came to work back the pillars. He believed that on several occasions the result had proved disastrous and large areas of coal were lost owing to the pillars being crushed, due no doubt to their very small size.

He (Mr. Harris) noticed that the roads are driven with an area of about 48 square feet, and that the pillars are left about 80 feet by 120 feet. This seemed to him the proper thing to do, so as to ensure the getting of the pillars in the future working. He should like to know whether Mr. Adamson had found that these pillars were of sufficient size to withstand the crush. He did not see how "wind-blast" could be avoided with such large areas, but accidents from this cause were reduced to a minimum by the precautions taken.

The working of a seam in Fifeshire had been referred to by Mr. J. B. Atkinson, of a similar thickness to the one described by Mr. Adamson, but that seam had about 3 feet of inferior coal, at the top and bottom, which was not worked. This reduced the seam to a thickness of about 12 feet, and he understood that it was successfully worked by the longwall system in two "carries." This, however, was very different from working a seam 21 feet thick, and he did not think that the longwall method could be successfully applied to seams approaching so great a thickness.

Mr. Thomas Adamson (Giridih, India) wrote that page 397, line 4 should read "the 15 feet of top coal."*

The fallen coal referred to by Mr. F. L. G. Simpson† is loaded out, by commencing from the bolt-holes and working towards the goaf. No one is allowed to work on the goaf-side of a fall of coal. When the coal has been cleared away from the bolt-holes and sufficient room has been made a cog (chock) of hardwood timber (10 inches by 5 inches by 5 feet) is built from the floor to the main roof. Cogs are built systematically, at intervals of 15 feet, whether the condition of the roof requires them or not. Props, 21 feet long and

* *Trans Inst. M.E.*, 1903, vol. xxv.

† *Ibid.*, 1903, vol. xxv., page 397.

6 to 8 inches in diameter, are also set between them, 5 feet apart, as the coal is being loaded out. It usually takes from 3 to 6 days to load out a fall of coal. The coal, after being dropped, is fenced off for 8 hours. It has been found by experience that *chowkidars*, 10 feet square, are large enough for the purpose of indicating when the roof commences to weight, and allow time for removing the workpeople to a place of safety. When the knobs show signs of crushing, they are not reduced any more, the timber is immediately drawn, and the coal dropped. The dimensions of the pillars enable them to withstand any crush.

The removal of large areas of coal has caused subsidence of the surface, which admits water into the mines; and this is drained by the pumping plant. A rainfall of 6 inches in as many hours (as stated by Mr Simpson) is not common in the Kurhurbaree coal-field. The average rainfall for the year—which practically all falls between June 15th and October 15th—is about 50 inches.

DISCUSSION OF MR. É. GOSSERIES' PAPER ON "THE GUIBAL FAN COMPARED WITH A DYNAMO."*

Mr. Gustave Hanarte (Mons, Belgium) wrote that a dynamo and a Guibal fan or a fan of any other system are not only dissimilar machines, but they possess entirely different properties.

When an exhausting or a forcing fan is put into movement by means of a motor on a passage, on a network of passages, or on a mine, for instance, the air, which is put into motion owing to the revolution of the wings, goes into the mine at atmospheric pressure and, after having traversed the length of the galleries, it reaches the fan with a loss of pressure or water-guage, H_m, which can be calculated as follows:— $H_m = KLPV^2/S$. P being the average perimeter of the galleries of the mine, V the velocity of the air per second, and S the average section of the galleries. V being equal to Q/S, the formula becomes: $H_m = KLPQ^2/S^3$.

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 568; and 1903, vol. xxv., pages 44 and 211.

This expression of the loss of pressure is the same as that which is used in hydraulics and for incompressible fluids; it is only approximate in the case of air and gases, because the volume occupied by a gas is inversely proportional to the pressure under which it exists, in accordance with the law known as that of Boyle or Mariotte. For example, a volume, Q, of 100,000 cubic feet of atmospheric air at a pressure of 33·90 feet of water may be assumed to traverse a mine by means of a fan and to reach the fan-inlet depressed by a quantity, H_m, equal to 0·66 foot of water. By the law, we write that 33·24 feet : 33·90 feet = 100,000 : x. Consequently, x equals 101,985 cubic feet; and the volume of the atmospheric air entering the mine has consequently increased by 1,985 cubic feet.

In order that the formula may be more correct, Q should represent the mean volume or (100,000 + 101,985 ÷ 2) 100,992 cubic feet.

To expel, into the atmosphere, the volume, Q, expanded at the water-guage, H_m, in the mine, it will be necessary to recompress this volume of air by means of the fan, that is to say, to reduce the volume by a quantity equal to 1,985 cubic feet. This work of recompression of the fluid and of expelling it into the atmosphere is expressed practically but erroneously by QH_m, which is the formula of the compression of liquids.

If it be assumed that the exhausted volume, Q, is proportional to the number of revolutions, N, of the fan, the value of H_m may also be expressed by the expression: $H_m = KLPN^2/S^3$.

Consequently, the potential which the fan must give to the air in order to expel it into the atmosphere is proportional to the square of the volume, Q, or to the square of the number of revolutions, N; and at all speeds, when the fan is exhausting air from the mine, the expression $Q/\sqrt{H_m}$ or $N\sqrt{H_m}$ will remain constant, as it will be possible to check on the manometer or water-gauge, if, of course, the orifice of the tube in the drift be placed suitably.

Let us now see what is the law which regulates the rotation of a dynamo. If a dynamo having a number of spirals, n, makes N revolutions per minute, the voltage or electromotive force, E, will increase according to the law: $E = n N \Phi$, Φ being the magnetic flux.

In the case of the dynamo, the potential will not conse-

quently increase according to the same law as in the case of the fan, and its increase will only depend upon the number of revolutions.

If, for example, the air reached, with 1 inch of water-gauge, the inlet of a fan making 100 revolutions, it will attain 9 inches of water-gauge when the fan is turning at a speed of 300 revolutions, and the air will have to undergo a corresponding recompression 9 times greater; whereas, if at a speed of 100 revolutions the electromotive force given by the dynamo is 10 volts, it will only become 30 volts at a speed of 300 revolutions, that is to say, 3 times greater.

In the case of a fan, the values are always constant:—

$\frac{100 \text{ revolutions}}{\sqrt{1}} = \frac{300}{\sqrt{9}} = \frac{N}{\sqrt{H_m}} = \frac{Q}{\sqrt{H_m}}$; and in the case of the dynamo, the constant values are:—$\frac{100}{10} = \frac{300}{30} = \frac{N}{E}$.

There is consequently a complete and essential dissimilitude between the working results given by a fan or a dynamo.

But there is something very strange, as in order to establish a certain similitude between these two machines, Mr. Gosseries places on each machine an adjunct, which, as it will be seen later, gives a bad result. In the case of the fan, he adds at the inlet a tube, *t*, which draws in air from the external atmosphere, the flow being regulated by a tap, *r* (Fig. 1, Plate I.). He adds to the dynamo on the collectors or brushes, the parts which conduct the electricity, (Fig. 2, Plate I.) a shunt.

Let us now examine, first, what influence the addition of a tube taking the external air and conveying it to the inlet will exert on the ventilation. Therefore, for the moment it will be supposed that the tap, *r*, of the tube is entirely closed; the fan will then only receive air which has traversed the mine, and the equation of the indicated work, T_I, determined from indicator-diagrams taken on the steam-engine, will be:—

$$T_I = T_{Rm} + T_{Rv} + QH_m + Qh_v \quad \ldots\ldots\ldots \quad (1)$$

T_{Rm} being the work which has been absorbed by the adverse metallic resistances of the motor, T_{Rv} the work absorbed by the metallic resistances of the fan due to its weight and the dimensions of the rubbing axle; QH_m the work absorbed by the friction of the air in the mine producing the depression or

loss of pressure, H_m; and Qh_v, the work absorbed by the friction of the air in the fan producing the loss of pressure (subsequent to the other) h_v. Only one of all these absorbed works is useful in the ventilation, that is QH_m, by means of which the air circulates in the mine and which determines the efficiency, R, determined by the formula:—$R = QH_m/T_r$.

All the other factors of the second member of the equation, lessen the efficiency, R.

The depression, H_m, to which the atmospheric air that has traversed the mine is subject can be checked on the manometer or water-guage, D, put into the inlet of the fan and having the mouth, A, of its orifice bent at an angle of 90 degrees, provided also with a bevelled collar, K, and placed in a plane parallel to the direction of the air-current (Fig. 3, Plate I.).

The air, expelled by the blades through the fan, is still subject to a depression of a new quantity, h_v, owing to the friction against the sides of the machine. It is very difficult, however, to measure this depression, h_v, as the orifice of the tube of the water-gauge should be placed immediately at the place where the air passes away from the blades of the fan.

The characteristic of the exhausting fan consists in recompressing and expelling the volume, Q, into the atmosphere, together with the quantity, $H_m + h_v$, by which the pressure has decreased owing to the friction of the mine and of the fan. Fig. 4 (Plate I.) is a sketch representing exhausting ventilation. The air enters the mine at A, at atmospheric pressure, p, reaches the inlet of the fan, B, expands by a quantity, H_m, leaves the blades at C, at a new pressure, h_v, and is expelled at D into the atmosphere through the chimney of the fan according to the curve of recompression, CD, which forces it out at atmospheric pressure.

Instead of the formula, QH_m, used for greater facility of calculation, the exact formula of the useful work of the extraction of the air and of its expulsion into the atmosphere ought to be written, if the recompression be taken into account:—pQ (log. nap. of $p/p - H_m$), P being the absolute pressure of the atmospheric air.

If the depressions which are to be surmounted were too great, as it is in the case of the extraction of the air out of the

nets of rarefied air, very important errors would evidently result by using the formula QH_m.*

Fig. 5 (Plate I.) is a sketch of forcing ventilation. The air enters the fan at B, and there it expands, by h_v, in traversing the fan, and is recompressed on account of its impulsion not only by the same quantity but also by a quantity H_m, which is used in overcoming the resistances of the mine, commencing from D; finally the air leaves the mine, at A, at atmospheric pressure. Generally, the work of the forcing fan consists in compressing the air by $h_v + H_m$, the same as in the exhausting fan.

Supposing now that the fan turns at the same speed, that the tap, r, is opened and air comes to the inlet of the fan through the tube, t, and through the mine, m (Fig. 1, Plate I.), the indicated power, T_i, will be constant; and this has been proved in the case of a fan working on resistances or mines of different temperaments. In experiments made on orifices of different areas, the indicator-diagrams taken on the steam-engine are superposed exactly on each other. The resistant powers, T_{rv}, and T_{rm}, will also be constant.

If h_t be the depression occasioned by friction in the tube, t, in a volume, q, arriving from the atmosphere at the inlet of the fan, without any profit, however, for the ventilation of the mine, the work of recompression that the fan has to supply in order to expel this new volume which is uselessly produced will be qh_t.

It will be then possible to lay down according to equation (1), the identical terms being eliminated, that:—

$$QH_m + QH_v = Q\,H'_m + (Q' + q)h'_v + qh_t \quad . \quad . \quad . \quad (2)$$

Q' being the new volume traversing the mine.

But if, for facilitating the demonstration, $\pm$, the tap, r, be opened in such a manner as to have the volumes $Q' + q$ equal to the volume, Q, which originally traversed the mine, the volume which will traverse the fan will be equal to Q, and the work which the fan will absorb on account of friction will be still Qh_v; $Q/\sqrt{h_v}$ being constant. It may then be laid down according to equation (2), that:—

* *Prolégomènes à l'Étude Rationnelle de la Ventilation: L'Air Raréfié: Théorie et Calculs faits pour sa Production, sa Transmission et son Utilisation: Résultats comparatifs de son Emploi et de celui de l'Air Comprimé pour la Transmission de la Force à Distance*, by Mr. C. Hanarte, 1886.

$QH_m = Q'H'_m + qh_t$; whence QH_m is greater than $Q'H'_m$.

The useful work will be therefore reduced and the efficiency will be:—$Q'H'_m/T_I$ equals R', whence R' is less than R. This decrease of the efficiency will increase as qh_t becomes greater, so that:—

$$\frac{Q}{\sqrt{H_m}} = \frac{Q'}{\sqrt{H'_m}}; \text{ and } \frac{Q}{\sqrt{h_v}} = \frac{Q' + q}{\sqrt{h_v}}.$$

He (Mr. Hanarte) thought that Mr. Gosseries made a great mistake in thinking that he could help the ventilation by creating a high water-gauge, h_t, in the tube, and this result he obtains by reducing the orifice of the tap, r. This mistake must be assigned to the fact that he considers the fan, and not the friction of the mine, as being the direct cause of the water-gauge, H_m. He confuses the static rarefaction and the ventilating rarefaction due to the air in movement, which engenders H_m. By thoroughly considering that any fan, whether exhausting or forcing, is a compressor of the air, which expands on account of the friction of the mine, it is impossible to make such a mistake.

In equation (1), the terms T_{Rv} and Qh_v characterize the fan. It is possible to evolve these characteristic terms:—(1) By forcing the machine to turn empty: the indicator-diagram, then taken, indicates the value of T_{Rm}; and (2) by determining carefully QH_m. In this operation, Q must be measured at the top of the chimney, the air having there taken up again its atmospheric density, and H_m must be determined by means of the end of the tube of the water-guage placed in the air-current as previously described. Indeed in the equation:—$T_{Rv} + Qh_v = T_I - (T_{Rm} + QH_m)$, T_{Rv} depends upon the weight of the machine and of the rubbing surfaces, and Qh_v upon the dimensions of the passages of the fan relatively to the volume, Q, which has to traverse it. The larger the volume, Q, the larger also must be the fan, all conditions being unchanged, the greater will become the quotient $Q/\sqrt{h_v}$, the smaller will become T_{Rv}, and the higher will be the efficiency of the fan and the useful work, QH_m.

Let us observe now the mode of working of a dynamo. In principle the magneto machine, in question, will have, for a constant number of revolutions, a constant difference of potential at the poles for a determined yield. Indeed, the electromotive

force equals $n\mathrm{N}\Phi$: n, being the number of spirals around the inductor; N, the number of revolutions per minute, and Φ, the magnetic flux. These three factors being constant, the electromotive force is, of course, constant.

If such a dynamo be supposed turning on an external determined circuit of a resistance R, the whole electromotive force of the dynamo will be, say, E; and the electromotive force at the poles will be e less than E for a yield of I ampères. The equation of the indicated power is:—

$$\mathrm{T_I} = \mathrm{T_{Rm}} + e\mathrm{I} + (\mathrm{E} - e)\mathrm{I};$$

$\mathrm{T_{Rm}}$ being the work absorbed in mechanical resistances; $e\mathrm{I}$ the useful work in watts; $(\mathrm{E}-e)\mathrm{I}$, the work absorbed in watts by the dynamo, that is to say, the ohmic resistances and the reactions of the inductor.

For the calculation of $\mathrm{T_{Rm}}$, you furnish by means of an external spring, an electric current in order to cause the dynamo to turn as a motor at the speed at which the machine has to turn as a generator; the mechanical resistances, $\mathrm{T_{Rm}}$, will then be measured in watts. We may then lay down the characteristic of the dynamo for a yield or useful work equal to $e\mathrm{I}/\mathrm{T_I}$. Supposing the inductor turning between the poles of the magnet produces a difference of potential, E, at the speed N; the circuit of lamps, l, l, l, l, of resistance, R, (Fig. 2, Plate I.) closed, and the useful voltage being e, at the collectors, the electric current will be:—$\mathrm{I} = e/\mathrm{R}$. If otherwise, we put on the collectors a resistance, r, in derivation, the combined resistances of the two circuits, R and r, will be (according to the derived currents) $\mathrm{R}r/(\mathrm{R} + r)$ and will be less than R. Consequently, the current which will be generated by the machine will be greater than before the derivation, taken for instance equal to J; and it will always be so, whatever the value given to the shunt or derivation may be. But, the magnet being fixed and the number of revolutions constant, the difference of potential produced, which we call e' will be less than e, and the useful yield for the indicated work will be less than before.

Indeed, $e'\mathrm{J}/\mathrm{T'_I}$ will be less than $e\mathrm{I}/\mathrm{T_I}$, e' being less than e; the ohmic resistances and the reactions of the inductor having increased according to J/I.

It has been seen from this analysis that the comparison

between the fan and the magneto dynamo is not a logical one, as previously remarked. The sole similarity that these two machines may have is due to the fact that they both revolve. The fan turning at a constant number of revolutions being able to give a fixed work, the addition of a tube causing useless work diminishes of course the useful volume, Q, which traverses the mine; and this decrease, multiplied by itself, gives the measurement of the decrease of the loss of pressure, H_m.

On the contrary, the consequence of adding a shunt to the dynamo has been to increase the yield in ampères and to have occasioned a fall of the potential proportional to the additional yield, the ohmic resistances and the reactions of the inductor having increased.

It is also very difficult to understand how it should be possible to maintain the constant potential of the machine by modifying the resistances of the shunt; in fact, the machine with independent excitation can be assimilated to the pile at constant speed and of variable yield, the curve of the potentials falling as shown in Fig. 6 (Plate I.). But any shunt put on the poles of the dynamo, whatever its resistance may be, diminishes the resistance of the external circuit according to the derived circuits, as has already been mentioned; thus the current increases, and there is consequently a decrease of potential.

The comparison between the fan and the dynamo can be set forth as follows:—

Fan.—(1) The water-gauge of the air corresponding to the compression, which the air has to undergo in the fan, is proportional to the square of the speed.

(2) The water-gauge is proportional to the square of the yield, or of the number of revolutions.

(3) The regulation is possible by means of the tube, in such a manner, if the same volume passes through the fan.

Dynamo.—(1) The electromotive force is proportional to the speed of the dynamo.

(2) The loss of pressure or electromotive force is proportional to the yield given by the dynamo.

(3) The regulation by means of the shunt, in order to have the same yield of the dynamo, is impossible.

To illustrate Mr. G. Hanarte's Paper on "The Guibal Fan compared with a Dynamo."

FIG. 4.—SKETCH OF EXHAUSTING VENTILATION.

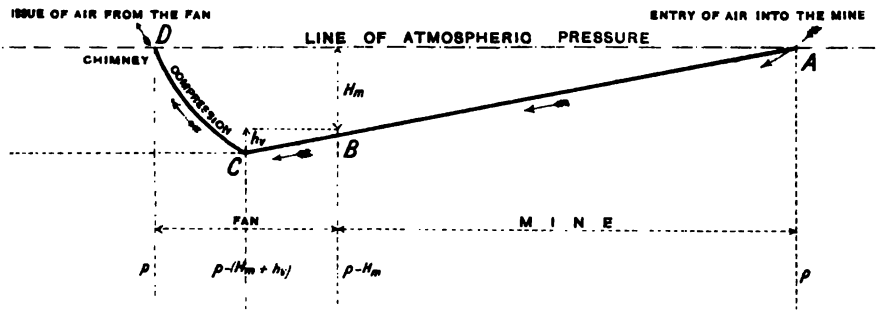
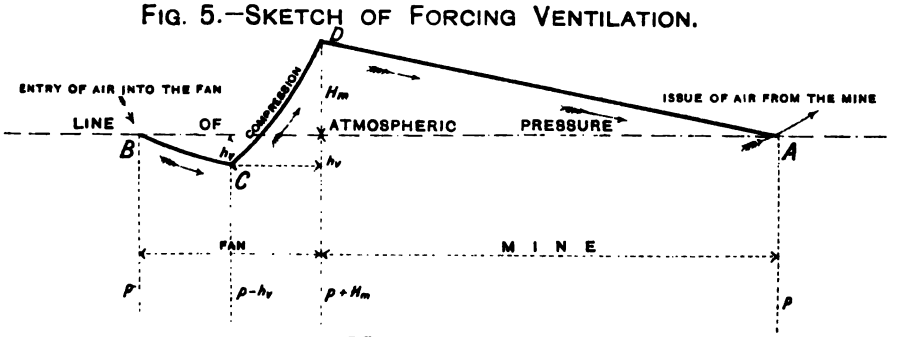


FIG. 5.—SKETCH OF FORCING VENTILATION.



REFERENCE.

The Arrows indicate the Direction taken by the Air; and, the Vertical Lines, the Absolute Pressures of the Air.

FIG. 1.

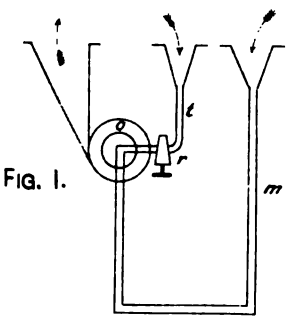


FIG. 2.

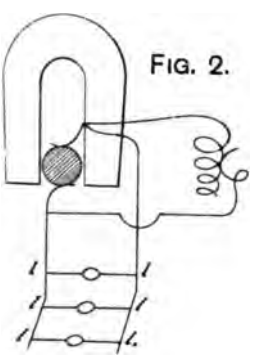


FIG. 3

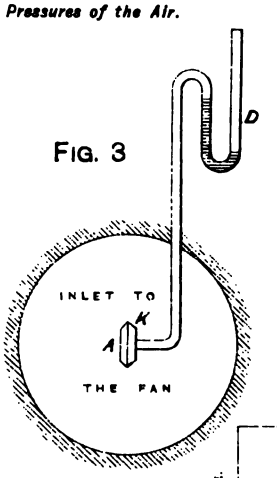
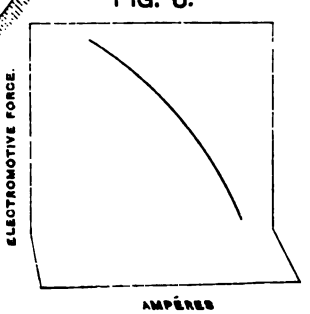


FIG. 6.



DISCUSSION OF MR. S. J. POLLITZER'S PAPER ON "THE UNDERLAY-TABLE."*

Mr. S. J. Pollitzer (Sydney, New South Wales), in answer to the various criticisms, wrote that Messrs. A. Lupton and J. Henderson recommend each a different instrument instead of the inventor's table; the first-named of these two gentlemen favours the Hedley dial, and the second the Henderson rapid traverser.† The writer had used the Hedley dial with success; but he did not remember having seen the Henderson traverser, which he supposed was in principle the same, though with considerable improvments. He (Mr. Pollitzer) was, however, of opinion, fortified by his experience, that neither of these instruments were suitable for such a shaft as the three described in his paper; and the writer distinctly stated in his paper that if an underlay shaft be of uniform grade right through from top to bottom, he would not suggest the use of his table.‡ Again, Mr. B. H. Brough, stated that it could be replaced by the recently invented theodolite of Mr. Dunbar D. Scott; now, with the greatest regard for that American gentleman's invention, the writer was compelled to confess that even this finest of mining instruments would not be in its proper sphere in such a shaft.§

And really it is of no use to make statements on one side and counter-statements on the other; among men of intelligence the proper course is to argue a point to the finish, and see on which side there is logic supported by facts. The primary reason that optical instruments are not adaptable for this work is that they have much too short legs; that they cannot be fixed in the surrounding country-rock like the underlay-table, but must be placed on a specially prepared platform, which can never be made rigid enough to avoid vibration; and, even if the legs were long enough, the observer must have a safe and pretty large platform to be able to use the telescope in all directions, which in nearly all cases will find itself in about fairly the middle of the shaft. The erection, therefore, of such a platform at every change of grade is an objectionable and heavy piece of work, causes vibration, and will make the results of the survey not absolutely but only problematically correct. With the writer's

* *Trans. Inst. M.E.*, 1903, vol. xxv., pages 24 and 196.

† *Ibid.*, pages 33 and 196. ‡ *Ibid.*, page 25. § *Ibid.*, page 35.

underlay-table all this labour is avoided, as no platform is required; one single stout board is nailed near the very footwall about 1 foot below the level of the underlay-table upon which the surveyor is safely sitting, and he can quite comfortably handle it. His assistants hardly ever want even a board, because the shaft-timbering will afford plenty of safe seats from which to manipulate the plumb-lines. The second objection is the awkwardness of tying in the telescope into the back-sight and revolving it for the front-sight, necessitating too much walking about a sensitive and delicate instrument in a cramped and dangerous position; and lastly the centreing of the instrument and ascertaining its axial height over the point which the writer questions can be done with precision. With the underlay-table all this is avoided. His critics ought to bear in mind one all-important fact, that even the smallest error made in reading an angle with a theodolite multiplies itself as the distance increases, but on the contrary—even assuming that the most trustworthy underlay-table assstant makes an error in marking the plumb-lines—such an error can at best only remain constant, and is not increasing.

Mr. B. H. Brough further remarks that the underlay-table is too costly; this contention is quite correct and applicable to the price given by the author, who ought also to have stated that much of the price he had to pay for it was due to discarding several parts and having them replaced by others. The price of the two telescopic tubes, for instance, was simply exorbitant, and yet the maker had hardly any profit on it, because such tubes had to be cast to order, as at that time none were to be had ready-made in Australia. Taking further into consideration the higher Australian rate of pay, the writer was of opinion that such a table made anywhere in Europe should not cost the half of what he had to pay for it.

Mr. J. Henderson said that a shaft, under an angle of 60 degrees and 100 feet long, will require a shifting of the table 25 times. The writer cannot assume that Mr. Henderson should have made so palpable an error in this most simple of calculations, which, at times, we are all apt to commit. But he (Mr. Pollitzer) accuses his critics of committing a most unpardonably gross breach of fairness and equity by criticizing without having properly read or correctly understood his paper. For

had Mr. Henderson done so, he would have seen in that paper an example quoted where the offset, which means the cosine of the underlay, is 5 feet 4½ inches, and can be got larger still. Therefore, there would be only nine or at the outside ten shiftings of the underlay-table, and not 25 as Mr. Henderson stated. Nor is Mr. Henderson right in all his other calculations, and the only angle suitable for one fixing is not at 88 degrees 51 minutes as he states, but it occurs at an angle of about 87 degrees 10 minutes.

Mr. A. Lupton states that the shaft should be at one's disposal for a considerable time. In the survey described by the author that was the case: however, there was absolutely no interruption in the usual working of the mine, and moreover it was an imposed condition that no interruption would be allowed. At that mine, the workings were carried on during two shifts only, and the night-shift, that is from 11 p.m. to 7 a.m. on the following morning, was the time allotted for surveying. Taking further into consideration that having to disengage the cage at night-time and re-engage it again in the morning (both operations wanting about an hour's time) the writer had barely seven hours at his disposal to carry out his tedious underlay-table operation. The average daily progress was at the rate of about 90 feet of depth per shift, proving that it was certainly a very slow process. Every plumb-bob point was permanently marked in the shoot by a nail, and was easily found at the next shift or, for that matter, many days later, so that there was no chance of loosing a connection or an impossibility of checking the work.

The writer confesses to having made a most grievous error in his illustration of the 12 miles base-line to the earth's quadrant being in a proportion of 1 to 8,300; for this is utterly wrong, and the proportion is barely like 1 in 500. The writer is at a loss to say how this error occurred, he is extremely sorry for it, and he hopes that the members will regard it as a clerical error.

Finally, the writer wishes to say that although his contribution was of the most modest kind, he feels an excusable satisfaction in having contributed his modest mite towards the advancement of the mining industry in general, and in particular towards that of sunny Australia, the fair country of his adoption.

DISCUSSION OF MR. S. J. POLLITZER'S PAPER ON "A MEASURING-TAPE, AND ITS USE IN MINE-SURVEYING."*

Mr. S. J. Pollitzer (Sydney, New South Wales), in answer to various criticisms, wrote that he could not boast of an experience of 20 years in underground surveying like Mr. H. Jepson, but he (Mr. Pollitzer) had enough experience with the theodolite in this kind of work to refute Mr. Jepson's positive assertion on the one hand, and on the other to assure him that this tape is the very outcome of his (the writer's) experience; and moreover Mr. Jepson admits that under the circumstances it is the most convenient instrument. And no doubt it is so, says the writer.

The writer is afraid that there is something of the disbelieving Thomas in his critics because he (Mr. Pollitzer) many months afterwards was informed of the success of his survey, as stated in his paper; and yet Mr. Jepson asserts that it is not possible to make as accurate a survey with it as by an optical instrument.

Mr. Jepson makes another assertion by saying that the wire "is free to move, as it ought to be, and it did move." To this it must be answered, "it did not move"; and to be sure of that, all the necessary precautions had to be taken, otherwise one would not be able to say whether it did move or not; because in such a very fine and thin wire one cannot possibly detect any slight movements with the naked eye in open daylight, far less in a dark mine lit up with a few candles. The two shafts were well ventilated, however, without any strong air-current; one of them was dry and the other was in fact so wet that the manager, at one time, grudged the excessive loss of oil in the bucket. Yet the writer could never discover an unsteadiness in the wire caused through the dropping water. Whenever the wire did happen to move, the cause invariably was accidental, say somebody would happen to knock against it, or a piece of some falling hard substance would come against it; but with the plummet in the oil, it did not take more than 2 minutes to be steady again as before. The period required to do it, is not too protracted; and one shaft, with 8 or 9 levels, can be surveyed or connected in one day of

* *Trans. Inst. M.E.*, 1903, vol. xxv., pages 17 and 205.

say 16 to 18 hours' duration, provided that all the necessary preparations have been made beforehand, and for this reason Sundays should be used when other days are not available.

The author wishes to add a material detail, which he omitted in his paper; and that is the means provided against swinging while the plummet is being slowly lowered. The wire is apt to become jammed on its wheel, and when that occurs in lowering, the wire must be forced by hand, and a swinging will be caused which may perhaps break the wire. To avoid so serious an accident to the wire, it is also carried over a small wheel, about 6 inches in diameter, from which the wire with its plummet is directly suspended. This small wheel rests on a sort of small cantilever fixed permanently to the sides of the trestle carrying the large wheel and the wire; and the small wheel is fixed on the cantilever at such a height that the common tangent to both wheels may be fairly horizontal; this tangent is represented by the wire going from the large to the small wheel, and it has a length of about 18 inches. If the wire becomes jammed on the large wheel, this tangential piece is used for forcing the wire, and the swinging of the plummet will thereby be avoided entirely.

Mr. W. M. BREWER's paper on "The Rock-slide at Frank, Alberta Territory, Canada," was read as follows:—

THE ROCK-SLIDE AT FRANK, ALBERTA TERRITORY, CANADA.

By W. M. BREWER, Victoria, British Columbia.

On the morning of April 29th, 1903, the outside world was startled by telegraphic reports that the top of Turtle Mountain in the extreme eastern portion of the Crows Nest coal-field, had been removed by volcanic eruption, that the town of Frank, a coal-mining camp situated at its base, had been destroyed, and that about 100 lives had been lost.

Fig. 1.—View of Turtle Mountain, after the Rock-slide.

That any eruption should have taken place in that particular region was beyond the belief of all geologists who had studied the formations: and engineers, who were familiar with the country, expressed disbelief as to the cause postulated in the newspaper dispatches for the terrible disaster which had visited the camp. When an investigation had been made later by com-

petent engineers it was found that we were correct, and, that instead of the phenomenon being volcanic it was really attributable to an enormous rock-slide which had precipitated from 60,000,000 to 80,000,000 tons of rock (as estimated by Mr. McConnell of the Dominion Geological Survey) on to that portion of the camp which was occupied by the miners' cottages, and entirely buried six of them.

Thorough investigation proved that the disaster had been so terrible that no less than 62 persons were killed, several severely injured, that the surface-plant at the Canadian-American Coal and Coke Company's mines was totally destroyed, as well as the cottages mentioned, and the rock which fell from the mountain covered nearly 2 square miles (Fig. 1.).

FIG. 2.—VIEW OF BOULDER, WEIGHING 15,000 TONS, MOVED 2 MILES BY THE ROCK SLIDE.

The 17 miners who were at work in the mine were entombed for about 12 hours, but succeeded in digging their own way out, for apart from the main entrance being blocked, the interior of the mine was but little affected.

The following is the story of Mr. Daniel M. McKenzie, one of the entombed miners, in his own language: –

Three other miners and myself were working in a crosscut off from No. 8 manway, when we were first aware that something unusual had happened. I was leaning against a chute just at the moment; suddenly there seemed to be a falling in of the hanging-wall, and I was imprisoned between a chute-board and the coal. The coal fell from the roof in large quantities, and I was badly squeezed. My companions helped me out; and believing that something had happened, but not knowing what it was, we started to make our way to the main entry. Reaching the entry, we started for the mouth of the tunnel.

On the way we encountered the other men on shift at the time. They were running toward the mouth of the entry. On reaching that point, we found our way blocked, as the entry was completely covered over. We turned to retrace our steps. The coal was falling from the roof, and progress was difficult. We waited for an hour, debating what should be done, and finally came to the conclusion that we ought to try to get out by way of No. 8 manway, which would lead us to an air-course, which we hoped would reach the surface. I found, however, that gas was accumulating when we reached the manway, and knew escape by that route was impossible. We, therefore, returned and attempted the lower entry. That we found to be rapidly filling with water. Sticking my knife into one of the timbers to enable me to judge as to the rapidity of the rise, we went back to the main entry. Some of the men were greatly excited, and talked in the irrational way that men will in such cases, but others with myself calmed them by telling them there was no danger. It was an occasion when a lie was justifiable, for had they been allowed to realize the danger they were in, there is no telling what might have happened.

After a time, I went down to the lower entry again to see how the water was rising. I found it quite alarming, and figured that, at the rate it was coming up, we might expect it to flood the mine to the day at about 4 p.m. As we had nothing to eat but the 5 horses being worked in the mine, which were still alive, I proposed killing one of them when we should need food, and in the meantime we should endeavour to dig our way out. We selected a place near the mouth of the main entry and started to work. We timbered as best we could as we went toward the surface. We had worked, changing hands, for something more than 5 hours, when I went in personally to do my turn. I was punching with a bar, when suddenly it went through, and a breath of air greeted me. I gave a few more punches, and a rock, big enough to have killed us all, fell in. I ducked back to save myself, and looking up saw that we had reached the surface. I called back to the others, and they literally went mad with delight. We were not long in getting to the outside.

Turtle Mountain reached an altitude of about 3,500 feet above the valley of the Old-man river, but to-day the summit is only about 2,500 feet above the valley. The slide is estimated to have carried away not only the original summit of the central peak of the mountain, but also a considerable mass of the mountain-side, as it spread out in fan-shape as the material slid down the slope. The wide portion of the fan reached a width of about 4,000 feet, and the débris covered an area of 2 square miles of the Old-man river valley.

Turtle Mountain is situated near the eastern boundary of the coal-field locally known as the Crows Nest Pass, and in the eastern foot-hills of the Rocky Mountains. The greater portion of this coal-field is on the western slope of the Rocky Mountains, where it covers a very large area. The portions situated on the eastern slope, so far as at present known, are not so extensive, nor are the number of seams so great as on the western side.

The Old-man or Crows Nest River has its source in Crows Nest Lake, at an altitude of 4,250 feet above sea-level. The middle fork of the river flows in a magnetic easterly direction, cross-cutting the formation through the mountains to the gap, about 14 miles from the lake. This gap is a defile excavated by erosion and the channel of the river through a high limestone-ridge. On the eastern side of the gap is situated the coal-mining camp of Frank, at the base of Turtle Mountain.

According to the late Dr. G. M. Dawson, Director of the Dominion Geological Survey, the Frank coal-field is a portion of the Crows Nest coal-field, and the most easterly productive portion so far as at present developed. At Crows Nest Lake, the Cretaceous rocks have been removed by erosion and the Carboniferous Limestone, on which the Cretaceous rocks were laid down, is exposed. To the eastward and beyond Turtle Mountain, the structure of the Cretaceous strata is that of an anticlinal, with the mountain peaks, composed of Carboniferous Limestone, towering above the Cretaceous rocks, which originally overlaid the limestone. The dip of the strata west of the Carboniferous Limestone range in which the gap is situated is to the west, at angles varying from 45 to 60 degrees, but eastward from the gap the strata dip toward the east at an almost vertical angle.

The coal-seam mined at Frank averages about 10 feet in thickness, and lies between the Cretaceous sandstones which form the eastern portion of the base of Turtle Mountain. The main workings in the coal-mine are tunnels driven parallel to the anticlinal axis, the lowest level being about 50 feet above the valley of the middle fork of the Old-man or Crows Nest River. From that level, mining operations have been extended upwards by stoping in a manner similar to the method in vogue in metalliferous mines. As the product of the mines has for the past two or three years averaged about

200 tons per day, it will be readily seen that considerable excavations have been made, with the result that that portion of the mountain has been honeycombed with tunnels, upraises and stopes. The main level is reported as having been driven for nearly 5,000 feet parallel to the stratification of the rocks.

This feature is referred to by the writer, because it seems probable that such extensive workings near the base of Turtle Mountain would have a tendency to weaken the power of resistance of the rocks and aid the weathering agencies resulting from heavy snowfalls, extreme frosts, and rainfalls which are continuously exerting their influence upon the limestone, and chiefly at the summit.

The face of Turtle Mountain which overlooks the town of Frank was, previous to the slide, very precipitous and presented a threatening appearance; but no one who saw it, as the writer did nearly three years ago, would have predicted that there was any danger of such an extensive slide as that which actually occurred.

The dimensions of the peak that broke away are about 2,000 feet across the face at the longest point, about 2,000 feet the greatest vertical height, and a maximum thickness of 1,000 feet.

Dr. EUGENE HAANEL (Superintendent of Mines, Ottawa) wrote that the summary of the official report on the recent disastrous rock-slide at Frank, Alberta, was as follows:--

Summary. The base of Turtle Mountain consists of beds of shales and sandstones of Cretaceous age, and the upper precipitous portion of beds of Carboniferous Limestone. The line of separation between the two series is the plane of a thrust-fault, along which the lower limestone-beds are highly contorted and shattered. In addition to dangerously steep slopes, the shattering due to faulting and the easy separation of rock-slabs along bedding-planes, Turtle Mountain is further weakened by several series of joint-planes, which traverse it in various directions.

The Rock-avalanche. At dawn, on the 29th of April, a great slice of the mountain, ½ mile long, over 2,000 feet in height and of great thickness, including the main central peak over 3,000 feet above the valley, precipitated itself with great violence into and across the valley below, overwhelming everything in its course. The debris, consisting of limestone-fragments, together with sediments ploughed up from the beds of Old Man river and Gold creek, now cover the valley to a depth of from 1 to more than 50 feet, over an area of about 2 square miles. About 70 lives and much property were destroyed. The disaster was due to a combination of causes cumulative in their effects. The chief of these was the

structure and condition of the mountain aided by exceptional atmospheric conditions, and in all probability by the weakening of the mountain as a result of mining operations.

Present Condition and Danger.—The ground between and adjoining the two remaining peaks is badly fractured. This fractured zone, surrounding the old break, is bound to fall away, but whether it falls gradually and in comparatively harmless blocks, or in large destructive masses, depends upon future conditions, which cannot be foretold. The fissures about the northern peak render the tunnel and lower portion of the town unsafe. The safety of Frank depends upon the stability of the shoulder from the northern peak. Apparently it is still secure, but the fissures some distance back from the northern peak may extend far enough north to weaken this shoulder. If these fissures show any sign of movement, the town ought at once to be evacuated. A succession of seasons with unusually heavy precipitation and rapid changes of temperature, a slight earthquake-shock, or creeping in the mine upon drawing the mined coal, may cause a jar that will dislodge this shoulder and start it on a career of destruction. Since this possibility must always overhang the town it would seem advisable to move the site a short distance up the valley beyond the reach of danger.

The CHAIRMAN (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Brewer for his interesting notes.

Mr. T. DOUGLAS seconded the resolution, which was cordially approved.

Mr. J. J. MUIR's paper on "An Improved Forced Method of Treatment of Low-grade Copper-ores" was read as follows:—

AN IMPROVED FORCED METHOD OF TREATMENT OF LOW-GRADE COPPER-ORES.

By J. J. MUIR.

Introduction.—In following out the writer's investigations on the treatment of low-grade copper-ores, brought under the notice of members in a recent paper,* he has now ventured to lay before them an improved method of forced extraction, which will fulfil the conditions required in treating these ore-bodies at a commercial profit.

As pointed out in his recent paper, a great bulk of this class of ore exists in various parts of Australia and Tasmania, and in no conceivable way can it be profitably dealt with by a smelting operation. After arriving at this conclusion, the writer turned his attention in an experimental way to the various methods in general use, with a view of ascertaining what percentage of copper-extraction could be obtained by them under the existing conditions, and also at what cost. In such methods as natural-leaching, salt-roast, ferrous sulphate and the principles laid down in the Hunt-Douglas process, the results at which the writer arrived fully established the claims of all of them to a good extraction under the conditions necessary for their operation.

It is, however, essential in proposing a method of treating these ores, that the commercial side of the problem should be equally as prominent and successful as the metallurgical one. It is in the satisfactory adjustment of these two opposing factors that a solution of this subject will be found, and as a consequence increased activity in the handling of these classes of ore.

After a patient review of the foregoing results and conclusions, it appeared to the writer that the lines on which investigation must be carried out in reconciling the two factors referred to, would be a careful consideration of the chemical conditions of the ores themselves.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 517.

The chief obstacle to be overcome, is the avoidance of the necessity of transporting large quantities of chemical re-agents to isolated positions for a treatment-process of the ores. The first cost of these re-agents in addition to their excessive transport charges in most cases renders it impossible to work out a satisfactory result. In conjunction with this difficulty, it is also necessary to arrive at a high-extraction of the copper, and, moreover, to show a speed in the work that will compare with that obtained in a smelting operation. The lines of investigation followed by the writer were therefore narrowed down considerably, and the issue on which a successful result would be arrived at clearly defined.

In considering the ores to be treated, the writer will confine himself to those typical of the West Coast of Tasmania, as these ores through their high silica-contents have baffled the smelter from the financial point of view. The writer does not suggest that these ores cannot be smelted, but that the operation results in a loss, when importing the necessary fluxes and fuels. The following is a typical analysis of these ores:—Silica, 48·00; copper, 4·56; iron, 13·29; sulphur, 12·60; alumina, 12·90; zinc, 1·17; manganese, 1·26; lead, 1·40; magnesia, 3·40; and oxygen and loss by ignition, 1·42 per cent.

It will be seen from the conditions, that these ores contain a large amount of sulphur, and, moreover, that by a judicious selection of a small proportion of the ores, as they leave the mine, the sulphur-contents can be considerably increased. This is the main condition by means of which the writer proceeded to work out a method for their profitable treatment.

In the following description of this process, the writer asks the indulgence of members in the necessity he is under of referring to well-known chemical and physical facts.

Operations at the Mine.— In extracting the ore from the mine by any of the usual systems, the aim should be to roughly and cheaply throw out the richer sulphides; to the extent of from 10 to 12 per cent. of the bulk of the ore treated. This smaller proportion is reserved for separate treatment, and the conversion of its sulphur-contents into sulphur dioxide (SO_2) fumes, and in turn their conversion into sulphurous acid (H_2SO_3) by solution

in water. The main bulk of the ore then goes forward to the regular plant.

Preparation of the Ore (Main Bulk).—The ore is first reduced to such a degree of fineness as the operator may find necessary, in order to expose the small sulphide-particles to the oxidizing flame of the reverberatory calciner. The machinery employed for this purpose can be adapted by any individual operator to suit himself. The writer would employ a Gates crusher followed by rolls, the schistose ores being soft and easily dealt with.

Calcination of the Ore.—In this connection, the writer would like to mention that the type of reverberatory calciner described by Dr. Peters in his *Modern Copper-smelting* is well adapted for this process. The stage to which the calcination must be carried is the first important consideration in dealing successfully with these ores. Provided that the last of the sulphides, as such, have been converted, it is a matter of no moment what proportion the residual oxides and sulphates bear one to the other, and the charges can be drawn at that stage. The sulphates being easily soluble, the writer provides for the attack on the oxides only.

Forced Leaching of the Ore.—The calcined ore is then transferred to the wooden leaching-vats (fitted with filter-bottoms), being discharged gradually and hot from the furnace on to the sulphurous acid (H_2SO_3) plus water-solution, derived from the ore that has been separately treated. The best mixing proportion is 200 gallons of solution to 1 ton of the roasted ore. The ore is covered, and the temperature considerably raised by the hot ore. The hot air-blast (described under the separate treatment) is then turned on, and the temperature is further raised. The copper oxides are attacked very rapidly by the sulphurous acid, following the equation $CuO + H_2SO_3 = CuSO_3 + H_2O$, and the extraction is completed in a very short time.

The hot oxygen of the blast tends to oxidize the surplus sulphurous acid (H_2SO_3) into sulphuric acid (H_2SO_4) and this is an advantage. The chilling effect of the cold solution on the hot air is greatly obviated by the initial raising of the temperature with the hot ore; and it will be found that a rapid extraction temperature is quickly reached.

Precipitating the Copper.—The strong copper-solution is then run into the precipitating-vats on to bars of pig-iron, and the temperature is again raised for a quick precipitation. One wash-water will recover the soluble copper in the dampness of the ore.

Separate Treatment of the Selected Portion of the Ores.—This portion being higher in sulphur-contents than the main portion of the ore-body, will be used for making the sulphurous acid necessary for leaching the whole of the ores. It is essential that as little of the sulphur contained in these ores should go to waste as possible, and it is, therefore, necessary in the arrangement of plant to provide for this. Pyrites, heated in a closed muffle or retort, does not give up the whole of its sulphur; but this result can be minimized by admitting a light pressure of compressed air, sufficient to overcome the head, due to the depth to which the fume discharge-pipe is immersed. The hot-air coil is arranged in the furnace-chamber of the muffle, so as to utilize the heat from the same fuel and minimize cost. Both the hot-air and fume discharge-pipes are led into the leaching-vats, and the water-charge is thus prepared for the reception of the hot ore from the calciner. The pressure behind both of these pipes is, of course, regulated to suit the mechanical conditions.

By the adjustment of these conditions to the ores under treatment, and according to the detailed plant which the writer has designed, a rate and cost of production can be obtained that will successfully deal with these ores.

Cost of Treatment per Ton of Crude Ore.—Under the conditions prevailing where these ores exist, the cost of treatment would be as follows per ton of crude-ore:—

	s.	d.
Crushing schistose ores	5	0
Reverberatory roast	3	6
Labour on leaching-vats	0	6
Hot air	0	6
Sulphurous-acid water	2	6
Pig-iron	2	0
Total	14	0

In addition to this, mining and delivery of the ore to the works by self-acting tram, would cost 10s. or, say, a total of 24s. per ton of crude-ore. Against this, a deduction of 4s. could be safely made on the copper-recovery from the muffle-roasted ores, leaving everything well on the conservative side.

Under average conditions, therefore, the total charges against the ore would be £1 per ton, and the precipitated copper will range in assay-value from 70 to 80 per cent. It would be the final product of this process, and the writer feels it unnecessary to follow it further on its course to refined copper. There is a ready market for this high-grade product, so that returns and final adjustments can be made at short notice.

Conclusion.—After a long and careful consideration of this subject, the writer has arrived at the conclusion that this process will fulfil the conditions necessary for the successful treatment of these ores. The action is rapid, continuous and complete, and the costs of running can be further minimized in many directions, not detailed in the general outline of this paper.

In operation, it is advisable to have an excess of sulphurous acid (H_2SO_3) in the solution, over and above what is necessary for the conversion of the copper oxides into their sulphites; and a day's experience of any ore will disclose the best conditions to an operator. A minor advantage of this process is that it is not based upon nicely-drawn chemical equations, with the corollary of high cost of supervision.

Dr. Edward Dyer Peters (Dorchester, Mass., U.S.A.) wrote that Mr. J. J. Muir now described the results that he had obtained in the wet treatment of copper-ores since his former communication.* Mr. Muir is evidently going through the same difficult and laborious investigations that have been undertaken, for the same purpose, in the United States during the past 25 years, and that have resulted in the two Hunt-and-Douglas methods, the McNeill process, the Van Arsdale process, and others. They nearly all of them depend upon the utilization of the sulphur in the ore or derived from extraneous ores, as a solvent for the copper—the sulphur being first burned to sulphurous

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 517.

acid gas, and the gas being converted into sulphuric acid by various means. Mr. Muir finds that he can obtain from the sulphurous acid derived from a careful roasting of a very moderate amount of pyrites, a sufficient quantity of sulphuric acid to rapidly dissolve the oxidized copper contained in the roasted ore. He effects this result by forcing a blast of heated air through an aqueous solution of sulphurous acid while in contact with the ore in the leaching vats. The copper is then precipitated by pig-iron in the usual manner.

Mr. G. D. Van Arsdale* proposes a still greater economy in this direction, though he had not tried it on a working scale at the time of writing the above article. Mr. Van Arsdale finds that a heated solution of cupric sulphate, when saturated with sulphurous acid gas under pressure, yields a considerable proportion of its dissolved metal in the shape of a precipitate of metallic copper, while free sulphuric acid is formed. The solution is then used to dissolve fresh ore: the operation thus being continuous. He gives the following formulæ in explanation of this interesting reaction:

$$3\,CuSO_4 + 3\,SO_2 + 4\,H_2O = Cu_2SO_3, CuSO_3 \text{ (cupro-cupric sulphite)} + 4\,H_2SO_4. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The sulphite precipitate then usually reacts further with the free acid formed thus:—

$$Cu_2SO_3, CuSO_3 + 4\,H_2SO_4 = Cu + 2\,CuSO_4 + 2\,H_2SO_4 + 2\,SO_2 + 2\,H_2O. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

He (Dr. Peters) had no doubt that Mr. Muir has already found, in common with all investigators in the United States, that there is little difficulty in selecting a method that will dissolve the copper from these low-grade quartzose ores. The sulphur in the ore will furnish the solvent required, and the ore can be easily and cheaply roasted in such a manner as to render 90 per cent. or more, of its copper-contents soluble in quite dilute acids.

The main difficulties lie in carrying out the operation rapidly and economically on a large scale, and are, for the most part, mechanical. Much money and labour has, in this country, been

* *The Engineering and Mining Journal* [New York], 1903, vol. lxxv., page 853.

expended in devising apparatus that shall burn the crushed pyrites thoroughly, and with an exactly regulated admission of air, so that a sufficiently concentrated sulphurous acid gas can be obtained from an ore low in sulphur. Still greater difficulties have been encountered in the leaching of the ore, wooden tanks, having proved unsuitable for these acid solutions, and, finally, iron vats, lined with heavy lead, have been employed. The presence of slimes, produced both by the ore itself, and by ferric salts precipitated from the solution, has been very troublesome, and at some works has called for an expensive installation of filter presses. But none of these difficulties are insurmountable, and those interested in the subject will hope to hear further results from Mr. Muir.

As regards the expense of the operation, he (Dr. Peters) did not know enough of local conditions to form an opinion about Mr. Muir's table of costs. But if the local price of fuel and labour are such that he can roast ore in a hand reverberatory furnace for 3s. 6d. per ton, the cost of fine-crushing even the hardest and toughest of schistose ores should not exceed 2s. per ton, and this should include repairs and renewals of machinery.

The CHAIRMAN (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Muir for his interesting paper.

Mr. T. DOUGLAS seconded the resolution, which was cordially approved.

Mr. R. R. SIMPSON's paper on "Well-sinking in the Punjab" was read as follows:

WELL-SINKING IN THE PUNJAB.

By ROB. R. SIMPSON.

A number of papers have, from time to time, appeared in the *Transactions*, dealing with the subject of sinking through sands and quicksands. It may therefore be of interest to members to have an account of the method of sinking adopted, under these conditions, from time immemorial, by the natives of the North-western Punjab, India.

The annual rainfall in many parts of the province does not exceed 5 inches, and, at times, no rain falls for years together. During the hot season, all surface-supplies, streams, tanks, etc., become dry. To obtain a constant supply of water, wells are sunk through the sands of the desert to a depth of from 50 to 80 feet; at which depth water is obtained from the river Indus, many miles distant.

A representative section of the strata to be sunk through is as follows: -

	Ft.	In.
Sandy clays	17	0
Sand	3	0
Sands and sandy clays	28	0
Sand, with ½ inch pebbles	1	0
Sand and sandy clays	5	0
Water-level		
Fine sands	12	0
Coarse sands	10	0
	76	0

The first excavation is made, 15 feet in diameter, to the bottom of the sandy clays (15 to 20 feet) and is not secured.

At the bottom of this excavation, a wooden curb is placed in position. This curb (Figs. 1 and 2) is composed of eight segments, A, and has an inside diameter of 9 feet. Each segment is 24 inches wide and 12 inches deep, and the joints between the segments are strengthened by iron strapping-plates, B (24 inches by 2½ inches by ⅜ inch). Each strapping-plate is

secured to the curb by four bolts, $\frac{3}{4}$ inch in diameter. To the lower and outer edge of the curb, an angle-iron cutting-ring, C, (3 inches by 3 inches by $\frac{1}{4}$ inch) is secured by bolts. Through the middle of each segment passes an iron bolt, D (1 inch in diameter and 10 feet long). The upper ends of these bolts are attached by nuts and washers to an iron ring, E ($2\frac{1}{2}$ inches by $\frac{3}{4}$ inch by 11 feet in diameter). These bolts and the ring are intended to strengthen the brickwork to be built upon the curb.

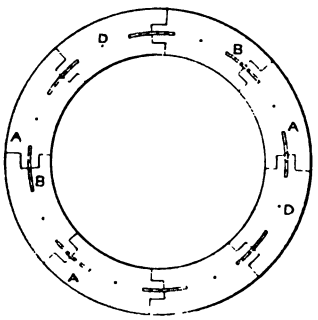


FIG. 1. PLAN OF WALLING-CRIB.

Upon the curb thus built up, brickwork, 20 inches wide, is built for a height of 20 feet; above this, the brickwork is reduced to a thickness of 15 inches; and the building proceeds until the top of the wall is about 8 feet above the level of the surface.

Excavation is then recommenced: the sand, when dry, being removed by means of *kodalis*, and when wet by means of shovels. The kodali is the tool used by earthcutters throughout India. The blade of this tool is set at an angle of about 70 degrees to the handle, and the kodali is used somewhat in the manner of a rake. The material loosened by the blow is filled into small baskets or bags. As the excavation proceeds, the brickwork settles from its own weight, and is constantly added to at the top, which is kept several feet above the surface. Verticality is universally preserved, and sticking of the casing is never experienced.

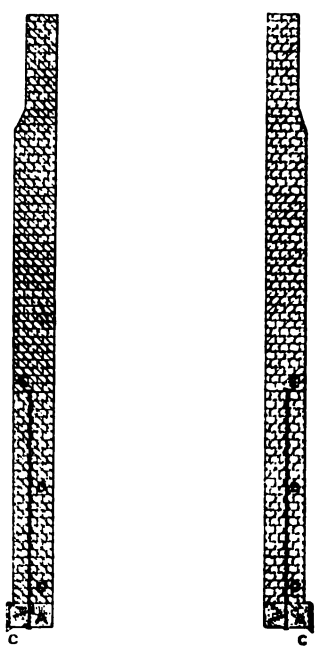


FIG. 2.—SECTION OF WALLING AND WALLING-CRIB, WITH CUTTING-RING. SCALE, 8 FEET TO 1 INCH.

The excavated material is removed from the excavation in bags by means of a rope passing over a pulley and dragged

horizontally along the surface by a gang of coolies. The pulley is supported by a rough-and-ready headgear, composed of two vertical poles, across which an horizontal pole is lashed (Fig. 3). The rope employed is three-stranded, and composed of the fibre of a reed-plant, known as *moomj*. Men are raised, standing with one foot in a loop and grasping the rope with both hands.

Water is raised by the wellknown ancient contrivance known as the Persian wheel, which consists of a broad wooden pulley, on an horizontal axis, upon which hangs a loose endless belt composed of plaited fibre-ropes. At equal intervals on this belt, earthenware-jars are fixed. As the wheel rotates, the belt and jars pass downward and enter the water, rising again to

Fig. 3. Raising the Excavated Material.

the surface on the other side of the wheel. As the jars pass over the top of the wheel, they are emptied into a launder and the water runs away. About 90 earthenware jars are usually employed; and three jars contain about 1 gallon of water (Fig. 4). The wheel is rotated by means of a whim, driven by oxen. The barrel of the whim is cogged, and engages with corresponding wooden cogs on the periphery of a pulley keyed to the shafts of the lifting-wheel, and the latter is by this means rotated. About 3,000 gallons of water per hour can be raised from a depth of 75 feet by this appliance.

It is not found possible to sink further down than 20 feet below water-level, as, at that depth, the sand commences to run.

The rate of sinking varies from 3 to 4 feet per day. The wages paid to sinkers are 5 to 6 annas (or pence) daily, and to the coolies, 3 annas (or pence) daily.

Fairly good bricks are made on the spot at a cost of 1 rupee 8 annas (2s.) per thousand.

FIG. 4.—PERSIAN WHEEL AND HEADGEAR.

The total cost of sinking and walling a well to a depth of 75 feet is 1,500 rupees (£100), and this amount includes the cost of a Persian wheel.

Mr. W. GALLOWAY (Cardiff) wrote that the adage "There is nothing new under the sun" was once more exemplified in Mr. Simpson's description of well-sinking in the Punjab. The same process was at one time the only one by means of which mining shafts could be sunk through watery running ground. Fortunately, we are now possessed of no less than three processes (the Triger, Kind-Chaudron and Poetsch), all infinitely better,

all equally applicable where the watery or running ground is not more than 90 feet deep, while the two last are applicable to depths of 500 or 600 feet or more.

It is remarkable that the curb at the bottom of the walling employed in the Punjab sinkings is fixed to the walling above it by means of bolts, in exactly the same way as in Europe. The cutting-ring is, however, very much smaller, the corresponding cutting-shoe in the European curb being both deeper and wider, in fact occupying the whole width of the curb. Brunel employed masonry-towers of this kind at both ends of the Thames tunnel—with a diameter of 50 feet, to sink to a depth of 42 feet into the bed of the river Thames.

At Ruhrort, it took eighteen years to sink a shaft to a depth of 430 feet by means of this process. It is now happily abandoned, except in simple cases where the depth to be sunk is not sufficiently great to warrant the application of more scientific methods.

The chain of buckets for raising water from the bottom was an apparatus of great antiquity. It was employed for irrigating and other purposes, from China to Morocco. He had seen it at work raising water from a well in the neighbourhood of Algiers; and it was used in the province of Sze-Chuen, in China, for raising brine from a lower to a higher level.

Mr. H. Aitken (Falkirk) wrote that the manner of sinking described by Mr. Simpson was the same as that adopted at Grangemouth colliery about 50 years ago. The only difference was that an iron crib was used, thicker walls, heavier binding bolts (which were carried to the surface), and at intervals of 6 feet a course of sandstone was placed. The pits at Grangemouth colliery passed through 150 feet of clay, sand, mud, etc., and that entailed the use of thicker walls, etc. In sinking such pits, in future, he (Mr. Aitken) would keep very much to the same plan.*

Mr. J. P. Kirkup (Burnhope) wrote that Mr. Simpson's paper contained an interesting description of a method of well-sinking now generally employed by engineers in building the foundations of the supporting pillars for bridges crossing the great rivers of India, where their beds afford no rocky foundations upon which to build. It is interesting to learn that an old

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 209.

device has been copied and improved upon by modern engineers. Where bridge-foundations are to be placed in the deep shifting sands of river-beds, ashlar-masonry wells of octagonal section are sunk, in some instances, 80 feet below the ordinary bed of the river without resting on solid strata, and have been found effective in resisting the enormous scour of those rivers when in flood. The method adopted is to start the masonry-wall upon wrought-iron cribs with a V shaped bottom of steel as a cutting edge. These are built and set level upon the site adopted; masonry is built upon this foundation, of corresponding form; and the sinking of the wells is effected by excavating the sand from the internal area of the crib. The wall and crib steadily sink downward during the process. When the water-level is reached, the material is removed by dredgers, and drawn from shallow depths by teams of bullocks.

FIG. 5.—SINKING FOUNDATION-WELLS FOR THE RAILWAY-BRIDGE OVER THE GODAVERY RIVER.

When it is necessary to sink the wells in the river, the cribs are extended into double caissons and floated into position. They are then filled with masonry, and as they subside into the bed of the river, additional segments are added and the masonry built up above the surface of the water The dredging is then effected by steam-hoists placed on craft anchored around. He had seen many of these wells built and sunk by Mr. Spring, in bridging the Godavery river; and that engineer assured him that wells had been sunk to a depth of 80 feet without varying more than a

few inches from the perpendicular. Of their stability he had ample evidence when he visited that bridge after completion, and saw the river in flood, occupying twelve spans of 300 feet each and running 56 feet deep at about 20 miles an hour. Fig. 5 affords some idea of the method. It shews dredging in progress from the top of the masonry, with a winch-engine in the background.

Mr. James Baird (Prestwick, N.B.) wrote that he had occasion some 11 years ago to sink a pit through 70 feet of mud, and in so doing adopted the method of sinking by a brick-cylinder. In the first place, a cast-iron leader or cutter was made in 6 pieces, and bolted together to form a ring, with an outside diameter of 18 feet; and this tapered inward from a sharp cutting-edge at the bottom, until at 5 feet up it measured 2 feet broad, forming a pit 14 feet in diameter. The weight of this casting was 18 tons, and upon it a brick-cylinder with walls 2 feet thick was built. Six railway-rails, 24 feet long, placed at equal distances, were bolted to the cast-iron leader; they were held in a vertical position, and built into the brickwork. When the wall approached to within 2 feet of the end of the rails, cast-iron plates, 2 feet long, 1 foot wide and 1½ inches thick, with a hole in the centre, were slipped over each of the rails, on to the brickwork, and a cotter was driven through the web of each rail, thus binding the brickwork together. Other lengths of rails were added and fish-plated together, and the brickwork was continued as before, plates being always added at every 24 feet to bind and strengthen the brickwork. Sinking and building went on simultaneously, and the verticality of the cylinder was maintained by the method of excavating only, no weights of any description being used. The brickwork was built at the surface-level, and sunk by its own weight as the excavation proceeded. It was a common occurrence for the brickwork of the cylinder to be left 8 feet above the surface-level at night, and on the following morning it would be found to have sunk down to the level of the surface or even below it. Three shifts of excavators to one of bricklayers were employed. The excavated material was removed by means of a steam jib-crane, wire-rope, and an ordinary tipping sinking-kettle. In 5 weeks' time, the cylinder reached a depth of 70 feet, where it stuck among large boulders and further it would

not move. Other methods were then adopted of sinking the pit to the rock-head and building upward, and widening out the pit to the required diameter until the two brick-cylinders met. It was interesting to note that 70 to 80 feet appeared to be the maximum depth to which cylinders of this description could be sunk, as shewn by the various papers that had appeared in the *Transactions* on this subject. The section of the strata sunk through was as follows:—

	Ft.	In.
Soil	1	0
Sandy clay	3	0
Muddy clay	6	0
Very soft mud	2	0
Soft dark mud	45	0
Sandy mud	3	0
Soft brown mud	9	0
Gravel-bed	1	6
Large boulders	2	0
Total	72	6

The CHAIRMAN (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Simpson for his interesting paper.

Mr. T. DOUGLAS seconded the resolution, which was cordially approved.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE HALL OF THE INSTITUTE, HAMILTON, AUGUST 13TH, 1903.

MR. HENRY AITKEN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—
Mr. JOHN PAUL, Lochgelly Coal and Iron Company, Lochgelly.
Mr. GILBERT YOUNG TICKLE, 21, Young Street, Edinburgh.
ASSOCIATE—
Mr. ANDREW ANDERSON, Calderside Terrace, Shotts.

DISCUSSION OF MR. H. D. D. BARMAN'S PAPER ON "THE RIEDLER PUMP."*

Mr. ROBERT MARTIN (Portobello) wrote that the Riedler underground steam-pump compared favourably with other pit-pumps in most respects. For a complete plant to raise, say, 600 gallons of water per minute to a height of 750 feet, the cost would be found to be very moderate. The only shaft-space required was room for two malleable-iron pipes, 6 inches in diameter, for steam and water. Compared with electric, hydraulic or compound-condensing pumps, working alongside of it, the superiority of the Riedler pump, in a low consumption of dross, was very marked. There had been no difficulty with the speed of the pump, and the wear-and-tear and attention required was no greater than for other types of pumps. It required less oil and packing, and the wearing parts were easily handled. The arrangement for raising the water from the sump to a tank on the pump-level was not peculiar to the Riedler pump.

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 238.

After over a year's working, the following improvements and alterations are suggested:—It would be very convenient if the valve-chests were fitted with doors, large enough to give access to the valves, without having to remove the air-vessels. There might also be a separate eccentric to drive the valve-controlling gear, instead of driving it (as at present) from the steam-valve eccentric; and some means of charging the air-vessels, almost as rapidly as the pump can fill the rising column.

Mr. Wm. Smith (Dalmellington) asked how far the Riedler pump would lift its water. He did not refer to the maximum distance, but a lift that would have the best results with the least attention or special appliances to assist it. After reading the paper, one is left with the impression that the pump to be efficient must have the water flowing into the suction-pot as at Niddrie, or have it standing at the line, AB, drawn through the suction-pot (Fig. 3, Plate X.),* that is, within a few inches of the lift. The very fact of special attention having been given by the designer of the pump, to secure large valve-areas in proportion to the plunger-area, shewed that the water was meant to be placed always convenient to the pump. If this were so, how would this high-speed pump act if placed in a dook or dip, which was in course of being driven, where, say, a 9 feet length of pipe had to be added daily to the suction-end and where, as often happened, it might have to go on half-air and half-water for most of the time? Mr. Barman might state whether a Riedler pump was working under these conditions, and where. If a steam-engine driving a Riedler pump required a very sensitive governor to check the speed immediately in the case of a burst casing or column, and the pump, as Mr. Barman stated, was better adapted for driving by electricity, how would it be governed? With reference to the charging of the air-vessel with the hydraulic-cylinder arrangement, if a pump be delivering water against a head of 1,200 feet (or, say, a static pressure of 600 pounds per square inch roughly, including friction) then, even with a fair length of cylinder, the charging process may be very tedious, more especially if the pump has to start and stop several times per shift. There was also the question of starting the pump, under a load against the head quoted,

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 248.

if driven electrically. The Riedler pump had its field, with high speed and mechanically-controlled valves, but would it be equally efficient under all circumstances connected with mining requirements?

Mr. H. D. D. BARMAN said that he could not very well criticize Mr. Martin's remarks, as he had spoken highly of the Riedler pump. He could not, however, agree with the idea of placing the valve-chests on the side, in every case. It could be done in some cases, where the pump was only working against a low head; but, when working against a head of 1,000 feet or more, it would introduce some undesirable features. Unfortunately, in the Niddrie pump, the air-vessel was not machined round the flange, and having come straight from the foundry, the flange was slightly tapered downward, so that the bolts, with little vibration, tended to slip out of the slot-holes. The bolts were not put through an ordinary round hole, which was a very common feature with other pumps. They were put into slits, so that if they were given, say, only one turn, they would come right out of their place. That idea was adopted with the view of economizing the time employed in getting at the valves. No doubt, Mr. Martin was troubled at Niddrie colliery by the low roof, but it might be explained, with regard to his complaint, that all that had to be done was to take a few bolts off the air-vessel, undo three pins in the delivery-valve and three pins in the suction-valve, and then they were able to lift the valves completely out of their seats. With reference to the eccentric, he (Mr. Barman) thought that Mr. Martin's hint was a very useful one—indeed he felt somewhat to blame, in that he had not himself already adopted the suggestion. It was evident from Mr. Martin's remark that the eccentric at Niddrie was overloaded, and it would therefore be desirable to put in a separate eccentric.

With regard to Mr. Smith's question, he did not quite understand whether that gentleman was referring to the head of the pump or the suction-lift. So far as the head was concerned, the Riedler pump had already pumped to a height of 3,000 feet. Certainly, the highest in this country was 1,660 feet, but he felt that no matter what was required in this connection the Riedler pump would be able to perform the task. As to the suction-

lift, only the other week, at Airdrie, a pump drew the water through 96 feet of piping, the lift in that particular instance being 15 feet. They could draw 24 feet without any trouble, and he had heard of as much as 30 feet being drawn. He could not quite understand how the idea had arisen that it was necessary to have the water flowing into the suction-pot of the Riedler pump. He might explain that the arrangement at Niddrie colliery was only adopted as an item of economy. Water had to be raised to the air-pump and condenser for condensing purposes, and it was usual to allow it to run back to the sump. The arrangement was sometimes adopted for steam-driven Riedler pumps: the vacuum raised the water to the air-pump, and this pump then delivered it 3 feet higher into a tank, whence it would run solid into the pump. Very large valves were used, usually about 10 per cent. larger than the plunger, the size of the valve, however, being contingent on the speed of the plunger. In the case of an electrically-driven pump, a constant-speed motor would be used, and this prevented the pump from running away. It might draw up—possibly cause thereby a little damage—but it could not run away. He had applied constant-speed motors to drive air-compressors, where the air-pressure varied from 5 to 90 pounds per square inch, simply by altering a pressure-governor. The alteration could be made in about three minutes, and no re-arrangement was necessary on the motor itself. In the case of starting and stopping, when the air-vessel was beyond the delivery-valve, the water and air could not flow back. In the case of dip-pumps, the air-vessel ought to stand charged, unless there was a leak through the pipes. The starting under the load was rather an important point with an electrically-driven pump. If care was not taken in the matter of starting, it was certainly not difficult to damage the motor. Personally, he would place a large safety-valve on the rising main, so that if the pump started the water suddenly, the safety-valve would relieve the excess pressure.

The PRESIDENT (Mr. Henry Aitken) thought that most engineers would agree that the Riedler was an excellent pump, which appeared to have a good future before it. Although he had never used it, he believed that there were many circumstances where it would be decidedly advantageous to do so.

DISCUSSION OF MR. BRAND'S PAPER ON THE "CALCINATION OF BLACKBAND IRONSTONE."*

Mr. J. CADMAN (Madeley) wrote that he had read Mr. Brand's paper with considerable interest, and was sure that it would be welcomed by everyone interested in blackband ironstones, as the recorded information, so far as he was able to ascertain, concerning the celebrated Scotch blackbands was very small. He had the pleasure of visiting several collieries working this class of ore in Scotland, and noted how very similar the method of working was, compared with the system in use in working the blackband ironstones of North Staffordshire. With regard to the surface-arrangements, however, there is a difference, owing to the fact that the North Staffordshire ore, after calcination, is hand-picked into three distinct classes of ore, namely: Puddle-mine, the perfectly calcined ore which, being almost pure peroxide of iron, is used in the puddling-furnace as "bottoming" or "fettling"; steel-mine, a harder and slightly over-burnt variety: and furnace-mine, corresponding to the char for blast-furnace use. As the marketable value of puddle-mine is about double that of furnace-mine, the engineer's object is to obtain the maximum percentage of the former class, and, for this purpose, the raw ironstone is put into the rucks or bins, with the utmost care, the hutch containing the ironstone being run to the front of the bin, and the ironstone practically placed there lump by lump by manual labour.† The bins are, as a rule, made somewhat larger than those described by Mr. Brand, and contain from 5,000 to 8,000 tons of raw ironstone. The actual process of calcination is almost identical with that described by Mr. Brand in his paper.

Reference was made to the basin-shaped deposits becoming coaly, or thinning out towards the margin. This observation, together with the fact that blackband seams frequently graduate partially and totally to parrot coal, helped, to his mind, to throw considerable light upon the probable origin of the deposition of these seams. Could Mr. Brand state whether the blackband seams of Scotland had ever been observed to turn into limestone, and what did he consider to be the minimum workable thickness (referred to in his paper) of a blackband seam? He trusted

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 253.

† *Ibid.*, 1901, vol. xxii., page 107.

that Mr. Brand would contribute a further paper dealing more fully with the conditions and methods of working these interesting seams.

Mr. Wm. Smith (Dalmellington) said that the amount of rubbish sent out of the pit per ton of ironstone raised seemed to be very large. With a fair thickness of stone and roads 60 feet apart, there should be ample stowage for any dirt got in the working, unless it came from stone-mines or falls of roof. He found, on a weekly output of 1,600 tons of blackband ironstone, that the refuse was 25 per cent. of the output, including dirt from all sources. The ironstone-seam was from 1½ to 3 feet thick, and did not possess a very good roof. With reference to the height of the bin before calcination, he found that 15 to 16 feet gave the most satisfactory results, with ore containing the same percentage of bituminous matter as in the Kilsyth stone. With this height of bin, less attendance was required at the top end for laying rails, etc. The cost of breaking was less per ton, and the char-filler with one holing might get a fall of char to keep him going for several days, the char being also of better quality. He noted that the rails were placed 3 feet below the hearth-level, but 6 or 7 feet was a more convenient distance, as it placed the top of the waggon on the same level as the hearth. Mr. Brand stated that the fire advanced along the bin at a quicker rate with the wind against it, but he (Mr. Smith) found that the fire advanced more quickly with the wind in its favour (blowing it like a bellows), although it burnt better with the wind against it—that is, more slowly and with better results.

If the percentage of bituminous matter falls, it may not be always convenient to raise or lower the height of bin coming from a fixed pit-head scaffold, but the depth of the broken stone on the top may be increased with advantage. During calcination, the fire must be kept travelling in a line parallel to that in which the bin has been laid down, for no matter how close together the roads are on the top of the bin, there are always gullets of round stone formed along each side, and the fire often refuses to cross these gullets at right angles: hence the necessity for always kindling the fire at the end of the bin.

Blackband ironstone had been worked at Dalmellington ironworks, when the thickness of the seam was as low as 9 inches:

operations had now, however, been abandoned. With reference to blackband ironstone turning into limestone, he might mention that it had been considered in Ayrshire that the Palacecraig ironstone (known locally at Dalmellington as the Craigmark ironstone) was a gas-coal at New Cumnock, about 10 miles away.

Mr. Mark Brand, replying to the discussion, said, with regard to the suggestion of dividing the char into different classes, they, at Kilsyth, had no great necessity to do that, as all the char was used in the blast-furnaces. Personally, he had never heard of any case where the blackband ironstone had passed into limestone. The thickness of a seam of ironstone, which it was possible to work, depended on the quality of the stone, which was very variable, particularly so in some districts. At some places, the ironstone, while maintaining nearly its usual thickness, proved so lean and poor that it became unremunerative to work it. He could make no definite statement as to the thickness at which it would be profitable to work a seam; but, in a general way, he considered that 9 inches of good ironstone would be the minimum thickness possible to be worked at present; and that the stone would require to be of exceptional quality to make the working profitable.

With regard to the high amount of rubbish, he might point out that the seam wrought in the Kilsyth district was thin, and as the men had to make a high holing, there was in consequence a good deal of rubbish to draw. In a seam, 3 feet thick, he could quite well understand that practically no rubbish would require to be drawn. The height of the bin depended very much on the quality of the stone and on the percentage of the bituminous matter in it—and this was a question upon which it would hardly be possible to make comparisons without complete analyses of the different ironstones. His statement with regard to the burning of the fire and the effect which the wind had upon it, was confined to this particular seam, and was not, on the other hand, intended to have a general application. They found that the fire advanced more quickly with the wind against it than with the wind in its favour, at Dumbreck pit. With the Banton ironstone, worked on Gartshore estate, they found that with the wind against the fire, the burning process was retarded so much that there was a difficulty in keeping the

fire burning, so this ironstone was broken 9 inches thick on the bottom of the bin, and the whole binful was mixed with about 1 per cent. of coal.

The PRESIDENT (Mr. H. Aitken) said, as regards the height of the bins of ironstone, that it depended upon the quantity of volatile matter and the quantity of fixed carbon in the stone. The process of calcination of an ordinary blackband ironstone resulted (1) in the burning of the hydrocarbons, and (2) in the burning of the fixed carbon or coke in the stone. In this process, the iron in the stone became malleable iron, and then by oxidation became oxide of iron, and this conversion of the iron into oxide of iron was unquestionably a great source of loss. He had for many years "coked" blackband ironstone and obtained oil and ammonia, retaining the fixed carbon in the ore, and then put it into the blast-furnace, and this resulted in a great saving of coal. He thought that the arrangement of bins described by Mr. Brand was excellent, and would result in obtaining as nearly as possible uniform calcination. In Mr. Smith's case, the ironstone contained a large quantity of hydrocarbons, which made it burn more rapidly, whereas in the ironstone referred to by Mr. Brand, the coaly matter was in an anthracitic condition, so that it burned much more slowly. As regards the change of ironstone into limestone, he knew of no instance of this in the Scotch coal-fields; the invariable rule being that when the character of a seam of blackband ironstone changed, its position in the strata was occupied by either a common coal or a parrot-coal or a mixture of coal, parrot-coal, ironstone and blaes.

Mr. JAMES BARROWMAN (the Secretary) said that there was a good example of a blackband ironstone-seam changing into coal in the neighbourhood of Hamilton. The seam of ironstone under the Splint coal, known as the Airdrie blackband, was worked 40 years ago at Quarter, and used in the blast-furnaces there. Within 2 miles of Quarter, the seam is being worked at present as a house-coal.

The discussion was then closed, and Mr. Brand was awarded a hearty vote of thanks.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT UNIVERSITY COLLEGE, NOTTINGHAM, AUGUST 29TH, 1903.

MR. G. ELMSLEY COKE, RETIRING-PRESIDENT, IN THE CHAIR.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1902-1903.

The following is a comparative summary of the number of members and the state of the finances for the last three years:—

	Year 1900-1901.	Year 1901-1902.	Year 1902-1903.
Honorary Members	14	15	15
Life Members	8	8	7
Members	244	252	259
Associate Members	5	4	3
Associates	64	65	59
Students	33	31	29
Totals	368	375	372

	£ s. d.	£ s. d.	£ s. d.
Cash Receipts	505 6 7	535 1 0	477 14 9
Cash Payments	474 18 4	467 4 7	450 8 6
Bank Balance	104 6 5	172 2 10	199 9 1
Invested Funds	640 0 0	640 0 0	640 0 0
Totals	£744 6 5	£812 2 10	£839 9 1

The following table shows the alteration in membership during the past twelve months. "Resigned" includes those who have ceased to be members under Section IV., Rule 7, and out of 22 resignations, 14 are due to this cause.

		Less			Add		
	1901-1902.	Dead.	Resigned.	Transferred.	Elected.	Transferred.	1902-1903.
Hon. Members	15	—	—	—	—	—	15
Life Members	8	1	—	—	—	—	7
Members	252	2	11	—	15	6	260
Associate Members	4	—	1	—	—	—	3
Associates	65	2	6	2	3	—	58
Students	31	—	4	4	6	—	29
Totals	375						372

In spite of the large amount of arrears of subscriptions unpaid, the financial position of the Institution has further improved, and the balance in hand is now practically £200.

The Annual Meeting of the Institution of Mining Engineers was held in Newcastle-upon-Tyne on September 16th to 19th, 1902, and the London Meeting took place on July 2nd, 3rd and 4th, 1903.

Local Meetings have been held as follows:—August 30th, at Matlock Bath, with a visit to the Mill Close lead-mine; December 6th, Nottingham; and March 7th, Mansfield, when Sherwood Colliery was visited. In addition to these, a Joint Meeting with the Midland Institute of Mining, Civil and Mechanical Engineers was held at Sheffield on April 25th.

At the beginning of the year the Council made mutual arrangements with the Council of the Midland Institute of Mining, Civil and Mechanical Engineers that the meetings of the two separate Institutions should be thrown open to members of either; consequently the following meetings have been available to members, including interesting excursions:—At Barnsley, on January 17th, 1903; and at Leeds, on July 17th, 1903. In addition to these, the Council of the Midland Institute of Mining, Civil and Mechanical Engineers kindly invited the members of this Institution to join a tour to the Düsseldorf Exhibition, etc., organized by them in September, 1902, and a considerable number of members accepted the invitation.

The Council wish to take this opportunity of thanking, in the name of the members, those gentlemen who have been good enough to entertain hospitably the members of this Institution, and to throw open their works for inspection; they also wish to express their appreciation of several invitations which have been received, but which it has not been possible at present to accept.

The following papers have been contributed to the *Transactions* by members of the Institution since the last report of the Council:—

"Sherwood Colliery." By Mr. J. W. Fryar.

"Sinking of the Rheinpreussen Colliery, Nos. IV. and V. Shafts." By Mr. W. H. Hepplewhite.

"Mining in Manchuria." By Mr. W. A. Moller.

The Council would like to express a wish that more papers be contributed to the meetings, as by such means only can the interest of the members be maintained.

Abstract of Accounts for Year ending July 31st, 1903.

Receipts.

	£	s.	d.
Balance brought forward	172	2	10
189 Members at £1 11s. 6d.	297	13	6
1 Member transferred from Associate	1	11	6
5 Members transferred from Students	7	17	6
3 Associate Members	4	14	6
47 Associates and Students	47	0	0
12 New Members and Entrance Fees	31	10	0
3 New Members transferred	4	14	6
8 New Associates and Students	8	0	0
6 Transfer Fees	3	3	0
The Butterley Company	5	5	0
Arrear Subscriptions paid	30	6	6
Subscriptions, paid in advance	15	0	6
Sale of *Transactions*, etc.	1	16	0
Midland Railway Debenture interest	15	1	4
Bank interest	4	0	11
	£649	17	7

Audited and found correct,

JOHN HALL,

JOHNSON PEARSON,

Auditors.

August 24th, 1903.

Expenditure.

	£	s.	d.
The Institution of Mining Engineers:—			
Call 1902-1903:—Vols. xxiv. and xxv.	275	10	0
,, 1901-1902 (Vols. xxii. and xxiii.)	15	4	0
Transactions sent on payment of arrears	6	0	0
Excerpts	0	9	4
Exchanges	3	6	8
Printing and stationery	24	9	11
Auditors	3	3	0
Reporting proceedings	4	19	5
Postages, parcels, etc.	17	13	2
Travelling and incidental expenses	12	15	11
Fees at meetings	2	15	0
Secretary's salary, assistance, office, &c.	75	0	0
Rent of room for storage of *Transactions*	2	10	0
Share of expenses of joint meeting	1	16	9
Fire insurance, deficit on railway tickets, &c.	0	19	1
Hire of Mechanics' Institution (deposit, for September meeting)	3	3	0
Bank commission	0	10	9
Cheque book	0	2	6
Balance	199	9	1
	£649	17	7

Dr. THE TREASURER IN ACCOUNT

	£ s. d.	£ s. d.
260 Members as per List, 1902-1903		
8 of whom are Life Members		
252		
8 of whom paid in advance		
244 Members at £1 11s. 6d.		384 6 0
4 Associate Members as per List at £1 11s. 6d.		6 6 0
96 Associates and Students, as per List		
3 of whom paid in advance		
93 Associates and Students at £1		93 0 0
6 Associates and Students—paid difference as Members and Transfer-fees		6 12 0
12 New Members and Entrance-fees		31 10 0
3 New Members Transferred		4 14 6
8 New Associates and Students		8 0 0
7 Members paid in advance, 1903-1904		11 0 6
4 Associates paid in advance, 1903-1904		4 0 0
The Butterley Company		5 5 0
		£554 14 0
Arrears, as per last Balance-sheet, 1901-1902	116 14 0	
Arrears considered irrecoverable but since paid ...	3 0 0	
		119 14 0

Audited and found correct,
JOHN HALL,
JOHNSON PEARSON.
AUDITORS.

August 24th, 1903.

£674 8 0

WITH SUBSCRIPTIONS, 1902-1903. Cr.

		Paid. £	s.	d.	Unpaid. £	s.	d.	Struck off List. £	s.	d.
189	Members paid, at £1 11s. 6d.	297	13	6						
42	Members at £1 11s. 6d.				66	3	0			
2	Members deceased							3	3	0
6	Members resigned							9	9	0
5	Members struck off							7	17	6
244										
3	Associate Members paid, at £1 11s. 6d.	4	14	6						
1	Associate Member struck off							1	11	6
4										
47	Associates and Students paid, at £1 ...	47	0	0						
6	Associates and Students paid, at £1, and transferred to Members ...	6	0	0						
28	Associates and Students unpaid, at £1				28	0	0			
2	Associates and Students deceased ...							2	0	0
2	Associates and Students resigned ...							2	0	0
8	Associates and Students struck off ...							8	0	0
93										
6	Associates and Students paid difference as Members and Transfer-fees ...	6	12	0						
12	New Members and Entrance-fees ...	31	10	0						
3	New Members transferred	4	14	6						
8	New Associates and Students	8	0	0						
7	Members paid in advance, 1903-1904 ...	11	0	6						
4	Associates paid in advance, 1903-1904	4	0	0						
The Butterley Company		5	5	0						
		426	10	0	94	3	0	34	1	0
Arrears		30	6	6	36	3	0	53	4	6
		456	16	6	130	6	0	87	5	6
								130	6	0
								456	16	6
								£674	8	0

The CHAIRMAN (Mr. G. E. Coke) moved the adoption of the report and the statement of accounts.

Mr. W. B. M. JACKSON seconded the motion, which was adopted.

The SECRETARY announced the election of the following gentlemen:—

MEMBERS—

Mr. ERNEST E. BRAMALL, Mining Engineer, Desford, Leicester.
Mr. WILLIAM BUMPSTEAD, Colliery Manager, Waverley Colliery, Darnall, Sheffield.
Mr. JOHN LAIRD CLOWES, Manager, Natal Merthyr Colliery, Waschbank, Natal.
Mr. DAVID DAVIES, Manager, New Campbell Colliery, Dundee, Natal.
Mr. WILLIAM DAWSON, JUN., Wollaton Collieries, Nottingham.
Mr. JOHN ELLIOT, Assistant Manager, Dundee Collieries, Dundee, Natal.
Mr. SAMUEL EVANS, Colliery Manager, Creswell Colliery, Mansfield.
Mr. ALBERT CHARLES FORD, Electrical Engineer, Queen's Chambers, Queen Street, Nottingham.
Mr. ROBERT STUART HILTON, Mining Engineer, Clay Cross, Chesterfield.
Mr. JOHN L. T. JOHNSON, Mining Engineer, c o Messrs. H. Fletcher & Co., 23, Old Jewry, London, E.C.
Mr. EDWIN CHARLES KNOX, Colliery Manager, Arley Colliery, Coventry.
Mr. WILLIAM HENRY MASCALL, Colliery Manager, Clay Cross Collieries, Chesterfield.
Mr. WILLIAM BENJAMIN PARKINSON, Mechanical Engineer, Dundee Collieries, Dundee, Natal.
Mr. WILLIAM PATTERSON, Manager, Central Colliery, Wessels Nek, Natal.
Mr. JAMES MALCOLM WHITEHOUSE, Mechanical Engineer, London Road, Coalville.

ASSOCIATES—

Mr. THOMAS BOYDELL, Surveyor, Shirebrook Colliery, near Mansfield.
Mr. THOMAS TEASDALE, Under Manager, St. George's Colliery, Hatting Spruit, Natal.

STUDENTS—

Mr. ARTHUR BERNARD HEWITT, Stanton Colliery, Burton-on-Trent.
Mr. HERBERT JOHN HUMPHRYS, Charnwood House, Ilkeston.
Mr. JOHN TOM LEE, Glapwell Colliery, Chesterfield.
Mr. GEORGE NORMAN LONGBOTHAM, Sharrow House, Sheffield.
Mr. LEWIS O. ROBERTS, Glapwell Colliery, Chesterfield.

RULES.

Mr. G. E. Coke moved and Mr. Jno. Piggford seconded the following addition to the rules, which was unanimously carried.

Members of any Federated Institution may, under special conditions, be admitted to membership of this Institution, upon special terms to be settled by the Council.

ELECTION OF OFFICERS, 1903-1904.

The report of the Scrutineers (Messrs. F. W. Wheatley and E. H. Staples) was read as follows:—

PRESIDENT:

Mr. W. B. M. Jackson.

VICE-PRESIDENTS:

Mr. G. J. Binns.	Mr. T. G. Lees.	Mr. G. Spencer.
Mr. H. R. Hewitt.	Mr. E. Lindley.	Mr. J. T. Todd.

COUNCILLORS:

Mr. G. H. Ashwin.	Mr. William Hay.	Mr. J. Piggford.
Mr. G. S. Bragge.	Mr. W. H. Hepplewhite.	Mr. C. Sebastian Smith.
Mr. J. W. Eardley.	Mr. C. F. Hewitt.	Mr. E. D. Spencer.
Mr. G. C. Fowler.	Mr. J. H. W. Laverick.	Mr. W. Wilde.

A vote of thanks was accorded to the Scrutineers for their services.

Mr. W. B. M. Jackson then took the chair, and proposed a vote of thanks to Mr. G. Elmsley Coke for his services as President during the past two years.

Mr. G. J. Binns seconded the resolution, which was unanimously adopted.

DISCUSSION OF MR. W. A. MOLLER'S PAPER ON "MINING IN MANCHURIA."*

Mr. W. A. Moller wrote that the following corrections should be made in his paper:—Page 141, line 6 should read, "2 feet" and lines 8 and 9, "with two steam-cylinders, 12 inches in diameter, by 2½ feet stroke," etc.; page 142, line 17 should read, "two steam-cylinders, 20 inches in diameter, and," etc.; and page 144, line 3, should read, "bad pump-men, roadmen and timbermen."

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 139.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING.

HELD AT THE QUEEN'S HOTEL, LEEDS, JULY 11TH, 1903.

MR. H. B. NASH, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

Mr. Wm. Sutton and Mr. John Wainwright were appointed scrutineers of the balloting papers for the election of officers, and also for representatives on the Council of The Institution of Mining Engineers for 1903-1904.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. WILLIAM ACKROYD, Mining Engineer, 51, Prudential Buildings, Leeds.

Mr. JOHN DENTON, Mining Engineer, Montgomery Chambers, Hartshead, Sheffield.

Mr. JOHN FAIRS, Colliery Manager, South Hiendley Colliery, near Barnsley.

Mr. SIDNEY GILL, Colliery Manager, Grimethorpe Colliery, near Barnsley.

Mr. WILLIAM HALLAS, Mechanical Engineer, Grimethorpe Colliery, near Barnsley.

Mr. SAMUEL JOSEPH RAYNOR, Assistant Colliery Manager, Sharlston Collieries, Normanton.

Mr. THOMAS WOOD, Engineer, Barley Brook Foundry, Wigan.

The Annual Report of the Council, and the statement of accounts for the past year were read as follows:—

THE COUNCIL'S ANNUAL REPORT.

The Council have pleasure in presenting to the members of the Institute their report on the work of the past year.

The number of members for the past two years are as follows:

	1901-1902.	1902-1903.
Members	256	258
Associate Members	10	11
Associates	13	15
Students	11	11
Totals	290	295

From this table, it will be seen that the membership has increased by 5 during the past year, which is satisfactory.

The Council regret to have again to state that there has been during the year some irregularity in the payment of subscriptions; but as the arrears only amount to £15, due from 10 members, the Council do not think that there is much to complain of, and only draw attention to the fact, seeing that delays in payment cause undue delay in the issue of *Transactions* to members thus in arrear. Of the £24 arrears of subscriptions due for 1901-1902, £10 10s. have been collected during the past year.

There is a balance in the bank of £191 10s. 11d. against £180 15s. 2d. at the end of the previous year, and all debts have been paid.

The following papers have been read during the year:--

"Presidential Address." By Mr. H. B. Nash.
"Notes on Systematic Timbering." By Mr. W. H. Pickering.

Interesting discussions have taken place on several papers.

In connection with the above, the Council most earnestly press members to try and make communications to the meetings on any subject or matter that may occur to them in the daily management of their collieries and works. There are many instances in which experience has proved that a small alteration made by a member in the machinery, methods of working, etc., has been a success, but the member thinks it too trivial to bring forward. The Council, however, wish to point out that such is not the case, for discussions generally arise on such alterations, which may lead to further improvement, or form the basis for some member to write a paper on.

The Council have, as pointed out in last year's report, agreed with the Midland Counties Institution of Engineers to hold Joint Meetings.

The Council wish to put on record that a very successful excursion took place to the Düsseldorf Exhibition and the Westphalian collieries, in September last. This was mainly due to the great kindness shewn by the Exhibition officials, colliery-owners, and mining engineers, at the various works visited. A detailed report, drawn up by Messrs. Nash, Walker, Habershon and Wilson, will appear in due course in the *Transactions*.

Dr. THE TREASURER (Mr. T. W. H. MITCHELL) IN ACCOUNT WITH THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS, 1902–1903. Cr.

	£ s. d.	£ s. d.
July 1st, 1902.		
To Balance at Bankers	180 15 2	
„ Cash in Treasurer's hands	1 3 7½	
		181 18 9½
June 30th, 1903.		
To Subscriptions for 1902-1903, 290 at £1 10s.	435 0 0	
„ Arrears, 1901-1902, 7 at £1 10s. ...	10 10 0	
		445 10 0
„ Sale of dinner tickets	14 15 0	
„ Wine account	5 13 4	
		20 8 4
„ Letting of room		1 7 6
„ Sale of *Transactions*		1 18 0
„ Share of cost of joint meetings with the Midland Counties Institution of Engineers		3 6 9
„ Bank interest		9 2 2
„ Düsseldorf dinner tickets and wine account		32 4 0
Examined and found correct, J. L. MARSHALL, M. H. HABERSHON, *July 7th*, 1903. AUDITORS.		
		£695 15 6½

	£ s. d.	£ s. d.
June 30th, 1903.		
By The Institution of Mining Engineers:—		
Call of 19s. per Member on 300 Members	285 0 0	
Balance of call for 1901-1902 ...	6 13 0	
Excerpt *Transactions*, etc.	5 5 0	
Proportion of cost of exchanging *Transactions* with other societies ...	3 6 8	
		300 4 8
„ Annual dinner		25 11 3
„ Printing and stationery		30 6 7
„ Rent of room		12 0 0
„ Reporter		7 0 0
„ Insurance		1 11 6
„ Cleaning		0 10 0
„ Electric light		0 2 0
„ Hire of rooms for meetings in Leeds, Sheffield and Barnsley		4 16 0
„ Secretary's salary		50 0 0
„ „ expenses		14 7 3
„ Stamps, telegrams, carriage, wrappers and sundries		18 15 3
„ Düsseldorf dinner		32 4 0
„ Prize for best paper, 1901-1902 (Mr. W. E. Garforth)		5 5 0
„ Balance at Bankers	£191 10 11	
„ Cash in Treasurer's hands	1 11 1½	
		193 2 0½
		£695 15 6½

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.
GENERAL STATEMENT, 1902–1903.

LIABILITIES.				ASSETS.					
1903.	£	s.	d.	1903.	£	s.	d.	£	s. d.
June 30th.—None.				June 30th.—By Cash in Bank	191	10	11		
„ To Balance, being capital	556	17	0½	„ „ „ Treasurer's hands ...	1	11	1½		
								193	2 0½
				„ „ Value of 6,996 parts of *Transactions*, at 1s. ...	349	16	0		
				„ „ Value of 115 copies of Narratives of Sudden Outbursts of Gas, at 1s.	5	15	0		
				„ „ Value of 116 copies of Committee's Report on Safety-lamps, at 1s.	5	16	0		
				„ „ Value of 16 copies of Report of French Commission on Use of Explosives, at 3s. ...	2	8	0		
								363	15 0
	£556	17	0½					£556	17 0½

Examined and found correct,
J. L. MARSHALL,
M. H. HABERSHON,
July 7th, 1903. AUDITORS.

Mr. M. H. Habershon proposed the adoption of the report.

Mr. J. L. Marshall seconded the resolution, which was carried unanimously.

ELECTION OF OFFICERS, 1903-1904.

The Scrutineers reported the result of the ballot, as follows:—

President:
Mr. H. B. Nash.

Vice-presidents:
Mr. J. R. Robinson Wilson. | Mr. M. H. Habershon. | Mr. Isaac Hodges.

Councillors.

Mr. J. E. Chambers.	Mr. R. H. Longbotham.	Mr. Charles Snow.
Mr. Thomas Gill.	Mr. J. L. Marshall.	Prof. G. R. Thompson.
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REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1903-1904.

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Mr. J. R. Robinson Wilson.

Prof. Thompson read the following paper on "The Transmission of Errors in Traverse-surveying":—

THE TRANSMISSION OF ERRORS IN TRAVERSE-SURVEYING.

By Prof. G. R. THOMPSON.

The conditions of mining are such that the mine-surveyor is unable to use the method of triangulation in making his survey of the underground workings, and is compelled to adopt some form of traverse-surveying, though for the surface he has the same freedom of choice as the land-surveyor. Traverse-surveying is, therefore, relatively of greater importance to the mine-surveyor than to others, and so may fittingly form a subject for discussion at our Institute. It is true that the art of surveying is old and that few new principles are likely to be brought forward in any paper on the subject, but the importance of keeping in view the fact that surveying instruments are not absolutely perfect and that surveyors are not infallible, is sufficient justification for bringing forward the subject of errors.

Traverse-surveying as performed in mines falls broadly into two classes:—(1) Where the bearings of the lines of the traverse are each determined independently of the others by means of the magnetic needle, where there is no local attraction. (2) Where the bearing of each line is used to determine that of every subsequent line, and the bearing of a line consequently involves the resultant of all the errors previously made. The bearings in this case are such as are determined by the magnetic needle, where there is local attraction, or by the theodolite (or its rougher equivalent, the dial with vernier-plate attached) in its various methods of use. In both classes, the lengths are usually measured with a steel chain or band.

Whatever method is used for measuring bearings (using the term "bearing" in a general sense to signify the direction of a line relatively to some fixed direction, whether measured directly or indirectly) and lengths, each of them will be subject to error. These errors will depend on the instruments used and the method

of using them, on the surveyor, and on the nature of the survey. For any particular case, the surveyor should decide what the total error is likely to be, and whether the system adopted gives him sufficient precision for the work in hand.

Let us examine the effect of making a small error in the bearing and length of a given line, and how similar errors made in other lines may be expected to affect the final result in a traverse: —

Firstly, suppose a small error be made in measuring the bearing. In Fig. 1 (Plate II.) let the arrow represent the meridian-line, and AB the true bearing of a line running in an easterly direction. If a small error, α, be made in the measurement of the bearing, and if no error be made in the length of the line, AB will come to the position AB′ or AB″, according as the bearing was measured too small or too great. The point B is moved from its true position to a point B′ or B″, at right angles to the line AB; and if α be measured in degrees, the error BB′ or BB″ is $AB \times \alpha \times 3{\cdot}14 \div 180$. Thus if α equals 1 minute of arc; BB′ equals $AB \times 3{\cdot}14/180 \times 60$ equals $0{\cdot}000{,}29 \times AB$ or AB/3,438 or 1 inch in 285 feet or 1½ feet in 1 mile.

Secondly, suppose a small error be made in measuring the length, the line may be measured too long or too short. In Fig. 2 (Plate II.), let AB represent the true length of the line, and AB′ and AB″ the measured lengths with errors BB′ and BB″. Calling the error in length β, it is clear that if AB be measured to 1 inch in 285 feet, there will be an error in the length of the line equal to that which an error of 1 minute in the bearing produces at right angles to the line.

Thirdly, suppose that both errors in bearing and length occur together as shown in Fig. 3 (Plate II.), B represents the true position of the point, BB′ the error in length, BB″ the error due to the error α in the bearing, and C represents the final position as wrongly determined; then BC the final error equals $\sqrt{BB'^2 + BB''^2}$. When the measurements of length and angle are done with corresponding degrees of accuracy, for example, if the bearing was read with an error of 1 minute and the length to 1 inch in 285 feet, the final error equals $1{\cdot}4 \times BB'$. But if

the error of one, the angle, say, is three times that of the other, the final error BC is only 1·05 greater than BB″, due to the angle alone. Consequently, increased accuracy, if desired, can only be secured by increasing the precision of the worst measurements, angle or length, as the case may be; and the time spent in increasing the precision of the more accurate measurement is merely time wasted.

If several successive and independent readings be made of the bearing and length of the line AB, with any instruments, the errors α in the angle and β in the length will be different from those shown in Figs. 1, 2 and 3, and each pair of errors will give a different final error. In a great number of measurements there will be a certain error, which will have as many greater as less. This error is commonly called the probable error. Its value can be determined by trial for any particular instrument (chain, dial or theodolite), observer and conditions. Having determined this, α and β in Figs. 1, 2 and 3 may be regarded as representing the probable errors in the measurement of bearing and length respectively. This may not be the value for any actual error made in surveying with these instruments, but it is an even chance that the actual error made is less than this, and it is more than a 4 to 1 chance that the error made is less than twice this value. Thus, the probable error affords a good guide in judging the reliability of the work.

Having considered a single observation, the more complicated case may be considered of a series of these observations giving the traverse. As in the previous case, it will be better to take the effect of errors in the measurements of lengths and angles separately, which can be done, since these errors produce displacements in the traverse-stations at right angles to each other. Let it be supposed that the traverse consists of a number of lines of about 3 chains in length running nearly due east and west. In measuring each line by the ordinary chain, there will be three or four applications of the chain, with the consequent uncertainty in the position of each end-point, due to changing slope of ground, irregular pull on chain, bad fixing of end, etc. The result is, say, that the line is measured too long or too short by 2 inches on the average, or with a probable error of about 1 in 1,000 on a 3 chains line. If the first line be made too long,

the next may be made too short by nearly the same amount: the errors thus tending to compensate. Now, perfect compensation cannot be expected; in fact, it is generally conceded that if measurements be made of n things in series under such circumstance, the uncompensated error left in the n^{th} observation is $\sqrt{n} \times r$, where r is the probable error of one observation. Thus, in the case in point, if the probable error in a 3 chains line equals 1 in 1,000, the probable error in length to the end of the second line is $300\sqrt{2} \div 1{,}000$; to the end of the third line is $300\sqrt{3} \div 1{,}000$; and to end of the nth line is $300\sqrt{n} \div 1{,}000$. The final error therefore may be said to vary as the $\sqrt{l}$, where l is the length of the traverse. In this case, the probable uncompensated error is $\sqrt{3l} \div 1{,}000$ chains.

Having determined the uncompensated error in length, the uncompensated error at right angles to this, due to error in bearing, must be determined. There are, here, two cases to consider, as already indicated. Taking a traverse with the magnetic needle, where there is no local attraction, each bearing is read independently of the rest, and is consequently unaffected by them; but every line, as plotted, starts from the end of the previously determined line. Consequently, the error in position of the second line will depend on the error in fixing the first line: the second error will, however, be of a compensating character, and the same law applies as in the measurement of length. Thus, if the probable error of measuring a bearing were 6 minutes, which gives a displacement of the end of the line of about 1/570th of its length, the probable error in the position of the second point would be $300\sqrt{2} \div 570$; of the third point, $300\sqrt{3} \div 570$; and of the n^{th} point, $300\sqrt{n} \div 570$. In Fig. 4 (Plate II.), these probable errors are plotted for 16 sights, and are shewn by the line marked "magnetic bearings."

It will be noticed that, at all points, the probable error due to measurement of the bearing, taken at 6 minutes, gives an error of position nearly twice as great as that previously assumed for the length. Under such circumstances increased accuracy must be sought, if it be required, by increasing the precision of measurement of the bearings. The combined error due to the length of the bearing, as above, would be, for n sights,

$$300\sqrt{n\left[\left(\frac{1}{570}\right)^2+\left(\frac{1}{1{,}000}\right)^2\right]}.$$

Taking a traverse with the magnetic needle, when there is local attraction, or with the theodolite or the vernier-dial, the bearings are each determined from the bearings of the previous line in the survey, the angles between two adjacent bearings only being determined independently one of the other. The errors made in the determination of these are compensating errors in the determination of the bearings; and, as before, for the position of the end of the line, now for the bearing of the line, the probable uncompensated error is $r \times \sqrt{n}$ where r is the probable error of determining one angle, and n is the number of angles measured. If the probable error in measuring an angle be 6 minutes, the probable error of the second bearing is $6\sqrt{2}$ minutes, of the third bearing $6\sqrt{3}$ minutes, and of the n^{th} bearing $6\sqrt{n}$ minutes. These uncompensated errors in the bearing give errors in position of the east-and-west traverse (an error of 6 minutes giving a displacement of about 4 inches in a line 3 chains long) as follows:—First line of 3 chains, end displaced 4 inches; second line, end displaced $4\sqrt{2}$ inches starting from end of first line, and the total displacement is $4(1+\sqrt{2})$ inches or $4 \times 2{\cdot}4$ inches; the total displacement of the third line is $4(1+\sqrt{2}+\sqrt{3})$ or $4 \times 4{\cdot}1$ inches; and of the sixteenth line, the total displacement will be 4×45 inches or 15 feet.

Instead of the probable error of one observation of an angle being 6 minutes of arc, by using a better instrument, as for example a 5 inches theodolite, with good conditions, the error might be $\frac{1}{3}$ minute, and the probable displacement of the terminal point of the traverse of sixteen sights would be about 45/3,438 chains or 12 inches. In Fig. 4 (Plate II.), the curve marked "theodolite bearings" shows the probable uncompensated error in a traverse of sixteen lines made under this system, and the figure gives the comparison between the probable errors of a traverse on this system and one with magnetic bearings, when the probable error of a single observation is the same in each case. This diagram illustrates clearly the different effect of the two laws of the transmission of error, and shows that, with long vernier-surveys, the instrument used should give great precision in the measurement of the angles.

The probable uncompensated error, in the measurement of the lengths, would also be represented by the same curve as that for the compass-survey, except that, now, the ordinates at each point would represent errors along the line and not displacements at right angles to it. It will be recognized, therefore, that if there is a long vernier-traverse, the error due to angular measurements increases with the number of sights. If there are sixteen sights, for example, and the error in length, as before, is 1 in 1,000, while the error in angle is nearly 3 minutes, giving a lateral displacement of 1 in 1,000 for the observation of one angle, the final probable uncompensated error due to length at the end of the sixteenth sight is only about $\frac{1}{11}$ of that due to the angles. If the lengths be measured to 2 inches in 3 chains, to have an equal error from the angular measurements, in sixteen lines of 3 chains length, the angles must be measured with a probable error of about 18 seconds in each.

The diagrams prove the marked superiority of the magnetic free-bearing needle method, where it can be applied, giving as it does both greater speed in measurement and less transmitted error. Unfortunately, the perfect absence of attraction is somewhat difficult to establish, and the needle is also subject to changes in the direction to which it points. When, however, the precision attainable with magnetic-needle readings is sufficient, the use of this at several points, free from attraction along the survey, breaks up a long traverse into independent sets of shorter traverses, each set being pieced on to the previous one, according to the first law. The accumulations of large angular errors is then rendered improbable.

Most of the surveys made in a pit will not be simple surveys on an approximately straight road, but around a closed polygon. The shape of this polygon will vary: sometimes it will be long and narrow, as in a survey out and back along the same or along two adjacent roads; sometimes it will be of equal dimensions in length and breadth, as in a traverse round a roughly square area. The probable error in the closure of the polygon will vary with its shape, but the two examples given above may be taken as extreme cases. From what has been said of the propagation of errors in a compass-survey, free from attraction, it is probable that the errors in the bearings are as likely to be made in a clockwise as in a counter-clockwise direction. The probable uncom-

pensated error in position of the end of the traverse is therefore the same in a traverse "out and back" as in the simple direct traverse (Fig. 5, Plate II.). The same remark also applies, to errors in the measurements of length. The same reasoning, however, does not apply to the traverse around the sides of the square, as the east-and-west lines cannot give compensating errors with the north-and-south lines, but only "compounding" errors, if such a term may be used. Fig. 6 (Plate II.) shows these for the magnetic bearings alone. Thus, if r be the probable error of one bearing (say 6 minutes of arc or 4 inches in a line of 3 chains), the probable error at B, the end of the northern side of the square (each side being 12 chains long) is $r\sqrt{4}$ or 8 inches. The probable error at C, the end of the eastern side of the square is $r\sqrt{4}$ in a northerly direction and $r\sqrt{4}$ in an easterly direction. The probable error at D, the end of the southern side of the square, is $r\sqrt{8}$ in a northerly direction (since the four sights, CD, in a westerly direction are compensating with the four sights, AB, in an easterly direction), and $r\sqrt{4}$ in an easterly direction. Similarly, the probable error at A (error in closing), the end of the western side of the square, is $r\sqrt{8}$ in a northerly direction, and $r\sqrt{8}$ in an easterly direction, or the total error AA′ is $\sqrt{(r\sqrt{8})^2+(r\sqrt{8})^2}$ or $4r$: the magnitude of the probable closing error being the same as before.

The case is very different, however, when the bearings are not measured independently of each other, as in the second class of traverses. Here, the angles are measured independently, their errors are compensating, but the probable uncompensated error in bearing has been shewn to be $r\sqrt{n}$; when, therefore, an error is established in a bearing tending, for example, to swing the survey round in a clockwise or in a counter-clockwise direction, this will tend to increase according to the above law, just as the northerly or easterly errors in the above case tended to increase. Thus, in the out-and-back survey of sixteen sights altogether (Fig. 7, Plate II.), if the errors made in the bearings tended to swing the survey round in a counter-clockwise direction, the error of position made in the first eight sights to the eastward according to this law would be $r(\sqrt{1}+\sqrt{2}+\sqrt{3}+\sqrt{4}+\sqrt{5}+\sqrt{6}+\sqrt{7}+\sqrt{8})$ in a northerly direc-

tion or $16{\cdot}1r$ to the north. In the return-bearings, the error still being counter-clockwise will make the sights now deviate to the south instead of to the north. The first back sight will give $r\sqrt{9}$ error to the south, the next $r\sqrt{10}$ and so on, so that the error to the south in the return-bearings will be $r(\sqrt{9}+\sqrt{10}+\ \ldots\ +\sqrt{16})$ or $28{\cdot}2r$. The final error is therefore $16{\cdot}1r$ northward and $28{\cdot}2r$ southward or $12{\cdot}1r$ southward. The great amount of compensation that has taken place in the survey due to the error reversing will be recognized, and the consequent small closing error from this cause for a given degree of precision in the measurements. The maximum error, in fact, in this example is to be found at the turning-point of the traverse, and not at the finish.

In the traverse round a square, for the same number of sights, and with a similar counter-clockwise error established (Fig. 8 Plate II.), starting from the corner at the end, B, of the northern side, there will be an error $r(\sqrt{1}+\sqrt{2}+\sqrt{3}+\sqrt{4})$, or $6{\cdot}1r$ to the north. At the end, C, of the eastern side, there will be, in addition to this error to the north, an error to the east of $r(\sqrt{5}+\sqrt{6}+\sqrt{7}+\sqrt{8})$ or $10r$. At the end, D, of the southern side, there will be an additional error of $r(\sqrt{9}+\sqrt{10}+\sqrt{11}+\sqrt{12})$ or $13r$ to the south, or a total error of $6{\cdot}9r$ southward and $10r$ eastward. At the end, A, of the western side there will be an additional error of $r(\sqrt{13}+\sqrt{14}+\sqrt{15}+\sqrt{16})$ or $15{\cdot}2r$ westward, giving a total error, AA′, in closing of $(15{\cdot}2-10=)$ $5{\cdot}2r$ westward and $6{\cdot}9r$ southward. The reversing nature of the errors is again apparent.

The combination with errors in measurement of length of sides may be made as in the previous cases.

Table I. gives the probable error of position of the various points of the traverse, due to errors in the angular measurements, the probable error of a single observation being assumed to give a displacement of unity. Thus, if the probable error of measurement were 1 minute of arc, and the traverse were made round a square, the error to be expected in closing a traverse of sixteen sights with perfect measurement of length by the vernier-method would be from column G:—$6{\cdot}9$ × length of each sight ÷ 3,438 eastward or westward, and $5{\cdot}2$ × length of each sight ÷ 3,438 northward or southward. These are the errors which may be

allowed in the latitudes and departures of the closing point, and since it is a more than 4 to 1 chance that twice these amounts are not exceeded, in such a case one may be very suspicious of a false reading in one line rather than of a general large error, and one should repeat the survey, instead of distributing the error over the whole survey.

A knowledge of the probable error of making the various observations, which together give the traverse-survey, and the way in which these affect the final result, is of use not only in indicating the precision required in the instruments and operations for any particular survey, and therefore determining the instruments that should be used for it and the time that should be spent; but it is of even more use as a test to apply to the results, to enable one to judge whether they are satisfactory or whether any unusual error has been made. An examination of the various parts, which together constitute the whole error in a single measurement and the way in which these are carried through the survey, will often decide the best method of using a particular instrument. In this connexion, it would also be useful to get information from the members as to the value of the errors produced by different instruments under different conditions and with different methods of use.

Considering the uncertainty of magnetic-needle measurements and the general presence of iron in mines, it follows that most of the surveys made will come in Class II., and, indeed, where great accuracy is essential the theodolite will in general be used. The preceding shows therefore that in a traverse, with many stations, a large accumulation in angular error is not improbable (large compared with the error of a single reading), and it has been shewn, in a long traverse with sixteen stations, that an accuracy in measuring the angles is required proportionately eleven times as great as that of measuring the length. Consequently, for this as for other reasons, the number of observations should be reduced as much as possible. Moreover, in good work, the amount of the angular error must always be determined by making a closed traverse, and taking an additional observation of bearing (by the continued bearing method) or of the angle between the first and last line, an angle which is not otherwise required for closing the survey. This error in angle is then tested by the rule given above, and,

if within the limits of error allowable, it is distributed over the bearings before the error in closure is determined. The distribution is usually made evenly over the whole of the traverse, but the error distributed is small.

To emphasize the different ways in which errors made in the various descriptions of traverses affect the final result, the writer took 99 counters numbered from 1 to 18, and representing errors ranging between $\frac{1}{8}$ and 4, the probable error being taken as unity. The numbered side was regarded as representing a plus error, the blank side a minus error of the same value; the number of counters for each value of error was taken in proportion to the chance of that error occurring, and ten lots of sixteen counters each were drawn, the errors being booked down in order. Not to be too tedious, the writer has selected the first, fifth and tenth. A plus error was taken as representing a turning of the survey in a clockwise direction, or displacing the end of the line to the right-hand. The sights were taken as of equal lengths, and the surveys were supposed to go eastward at the start, as in the previous examples. Tables II., III. and IV. record the errors in the different surveys. A comparison of these numbers will show the different effects on the final point of the same error in a reading of the angles under the different condition.

TABLE I.

A.	B.	C.	D.		E.		F.				G.			
			North.	South.	North.	South.	North.	South.	East.	West.	North.	South.	East.	West.
1	1·0	1·0	1·0	..	1·0	..	1·0	..	..	..	1·0	..	..	..
2	1·4	2·4	1·4	..	2·4	..	·4	..	..	..	2·4	..	..	..
3	1·7	4·1	1·7	..	4·1	..	·7	..	..	..	4·1	..	..	..
4	2·0	6·1	2·0	..	6·1	..	·0	..	..	..	6·1	..	..	..
5	2·2	8·3	2·2	..	8·3	..	..	..	1·0	..	..	..	2·2	..
6	2·4	10·7	2·4	..	10·7	..	..	..	1·4	..	..	..	4·6	..
7	2·6	13·3	2·6	..	13·3	..	..	..	1·7	..	..	..	7·2	..
8	2·8	16·1	2·8	..	16·1	..	..	..	2·0	..	..	..	10·0	..
9	3·0	19·1	3·0	..	13·1	..	2·2	..	..	..	3·1	..	..	..
10	3·2	22·3	3·2	..	9·9	..	2·4	..	..	..	..	0·1	..	..
11	3·3	25·6	3·3	..	6·6	..	2·6	..	..	..	..	3·4	..	..
12	3·5	29·1	3·5	..	3·1	..	2·8	..	..	..	..	6·9	..	..
13	3·6	32·7	3·6	..	..	0·5	..	..	2·2	..	..	..	6·4	..
14	3·7	36·4	3·7	..	..	4·2	..	..	2·4	..	..	..	2·7	..
15	3·9	40·3	3·9	..	..	8·1	..	..	2·6	..	..	..	..	1·2
16	4·0	44·3	4·0	..	..	12·1	..	..	2·8	..	..	..	..	5·2

A.—Number of line. B.—Probable error in position of the end of each line, due to error in reading the magnetic bearing; and also probable error in the bearing due to error in reading the angles in a traverse (Class II.). C.—Probable error in position in a straight-line traverse to eastward, due to errors in angles (Class II.). D.—Probable error in position, due to errors in magnetic readings in a traverse of eight sights out and eight sights back. E.—Probable error in position in a similar vernier-survey (Class II.). F.—Probable error in position for a magnetic survey round a square. G.—Probable error in position for a vernier-survey round a square.

TABLE II.

A.	B.		C.		D.		E.		F.		G.				H.			
			South.	North.	North.	South.	North.	South.	North.	South.	North.	South.	East.	West.	North.	South.	East.	West.
	+	−	+	−														
1	..	0·5	..	0·5	0·5	..	0·5	..	0·5	..	0·5	..	..	..	0·5	..	..	..
2	..	0·5	..	1·0	1·5	..	1·0	..	1·5	..	1·0	..	..	..	1·5	..	..	..
3	..	1·1	..	2·1	3·6	..	2·1	..	3·6	..	2·1	..	..	..	3·6	..	..	..
4	2·5	..	0·4	..	3·2	..	..	0·4	3·2	..	..	0·4	..	..	3·2	..	..	..
5	0·3	..	0·7	..	2·5	..	..	0·7	2·5	..	..	..	..	0·3	..	..	..	0·7
6	..	0·1	0·6	..	1·9	..	..	0·6	1·9	..	..	..	..	0·2	..	..	..	1·3
7	..	1·1	..	0·5	2·4	..	0·5	..	2·4	..	..	..	0·9	..	..	..	..	0·6
8	..	0·9	..	1·4	3·3	..	1·4	..	3·3	..	..	..	1·8	..	..	..	0·8	..
9	1·1	..	..	0·3	4·1	..	2·5	..	3·5	..	0·7	..	..	..	2·9	..	..	..
10	..	1·7	..	2·0	6·1	..	0·8	..	1·5	..	..	1·0	..	..	0·9	..	..	..
11	0·3	..	..	1·7	7·8	..	1·1	..	..	0·2	..	0·7	..	..	..	0·8	..	..
12	..	0·9	..	2·6	10·4	..	0·2	..	..	2·8	..	1·6	..	..	..	3·4	..	..
13	..	0·3	..	2·9	13·3	..	..	0·1	..	5·7	..	..	1·5	..	..	..	..	2·1
14	0·1	..	..	2·8	16·1	..	..	0·0	..	8·5	..	..	1·6	..	..	..	..	4·9
15	..	0·3	..	3·1	19·2	..	..	0·3	..	11·6	..	..	1·2	..	..	..	..	8·0
16	..	2·1	..	5·2	24·4	..	..	2·4	..	16·8	..	..	..	0·9	..	..	..	13·2

A. - Number of line. B.—Value of error drawn, the probable error being 1. C.—Error of position in an easterly magnetic survey given north and south, and also error of bearing in the vernier-survey, given + or −. D.—Error of position in an easterly vernier-traverse of sixteen sights. E.—Error of position in an easterly magnetic traverse of eight sights out and eight sights back. F.—Error of position in a vernier-traverse of eight sights out and eight sights back. G.—Error of position in a magnetic traverse round a square. G.—Error of position in a square traverse (Class II.).

TABLE III.

A.	B.		C.		D.		E.		F.		G.				H.			
			South.	North.	North.	South.	North.	South.	North.	South.	North.	South.	East.	West.	North.	South.	East.	West.
	+	−	+	−														
	0·3	..	0·3	..	..	0·3	..	0·3	..	0·3	..	0·3	..	..	..	0·3	..	..
	0·1	..	0·4	..	..	0·7	..	0·4	..	0·7	..	0·4	..	..	..	0·7	..	..
3	..	1·1	..	0·7	..	0·0	0·7	..	..	0·0	0·7	..	..	..	..	0·0	..	..
	..	0·5	..	1·2	1·2	..	1·2	..	1·2	..	1·2	..	..	..	1·2	..	..	..
	1·3	..	0·1	..	1·1	..	..	0·1	1·1	..	..	..	..	1·3	..	..	..	0·1
	..	1·1	..	1·0	2·1	..	1·0	..	2·1	..	..	..	..	0·2	..	..	0·9	..
	..	0·7	..	1·7	3·8	..	1·7	..	3·8	..	..	..	0·5	..	..	..	2·6	..
	0·9	..	..	0·8	4·6	..	0·8	..	4·6	..	..	..	..	0·4	..	..	3·4	..
9	..	2·7	..	3·5	8·1	..	..	1·9	1·1	..	..	1·5	..	..	..	2·3	..	..
10	..	0·3	..	3·8	11·9	..	..	2·2	..	2·7	..	1·8	..	..	..	6·1	..	..
11	..	0·1	..	3·9	15·8	..	..	2·3	..	6·6	..	1·9	..	..	..	10·0	..	..
12	..	0·3	..	4·2	20·0	..	..	2·6	..	10·8	..	2·2	..	..	..	14·2	..	..
13	0·7	..	..	3·5	23·5	..	..	1·9	..	14·3	..	..	0·3	..	..	..	..	0·1
14	2·3	..	..	1·2	24·7	..	0·4	..	..	15·5	..	..	2·6	..	..	..	..	1·3
15	..	0·3	..	1·5	26·2	..	0·1	..	..	17·0	..	..	2·3	..	..	..	..	2·8
16	..	0·5	..	2·0	28·2	..	..	0·4	..	19·0	..	..	1·8	..	..	..	..	4·8

A.—Number of line. B.—Value of error drawn, the probable error being 1. C.—Error of position in an easterly magnetic survey given north and south, and also error of bearing in the vernier survey, given + or −. D. Error of position in an easterly vernier-traverse of sixteen sights. E.—Error of position in an easterly magnetic traverse of eight sights out and eight sights back. F.—Error of position in a vernier traverse of eight sights out and eight sights back. G.—Error of position in a magnetic traverse round a square. G.—Error of position in a square traverse (Class II.).

TABLE IV.

A.	B.		C.		D.		E.		F.		G.				H.			
	+	−	South. +	North. −	North.	South.	North.	South.	North.	South.	North.	South.	East.	West.	North.	South.	East.	West.
1	0·7	..	0·7	..	..	0·7	..	0·7	..	0·7	..	0·7	..	..	..	0·7	..	..
2	..	0·3	0·4	..	..	1·1	..	0·4	..	1·1	..	0·4	..	..	..	1·1	..	..
3	..	1·3	..	0·9	..	0·2	0·9	..	..	0·2	0·9	..	..	..	..	0·2	..	..
4	..	0·5	..	1·4	1·2	..	1·4	..	1·2	..	1·4	..	..	..	1·2	..	..	..
5	..	1·3	..	2·7	3·9	..	2·7	..	3·9	..	..	..	1·3	..	..	..	2·7	..
6	0·1	..	..	2·6	6·5	..	2·6	..	6·5	..	..	..	1·2	..	..	..	5·3	..
7	..	1·3	..	3·9	10·4	..	3·9	..	10·4	..	..	..	2·5	..	..	..	8·2	..
8	0·1	..	..	3·8	14·2	..	3·8	..	14·2	..	..	..	2·4	..	..	..	13·0	..
9	1·1	..	..	2·7	16·9	..	4·9	..	12·5	..	2·5	..	..	..	..	1·5	..	..
10	0·5	..	..	2·2	19·1	..	5·4	..	10·3	..	3·0	..	..	..	..	3·7	..	..
11	0·7	..	..	1·5	20·6	..	6·1	..	8·8	..	3·7	..	..	..	..	5·2	..	..
12	0·7	..	..	0·8	21·4	..	6·8	..	8·0	..	4·4	..	..	..	..	6·0	..	..
13	0·1	..	..	0·7	22·1	..	6·9	..	7·3	..	..	..	2·5	..	..	..	12·3	..
14	..	0·1	..	0·8	22·9	..	6·8	..	6·5	..	..	..	2·4	..	..	..	11·5	..
15	..	0·3	..	1·1	24·0	..	6·5	..	5·4	..	..	..	2·1	..	..	..	10·4	..
16	2·9	..	1·8	..	22·2	..	9·4	..	7·2	..	..	..	5·1	..	..	..	12·2	..

A.—Number of line. B.—Value of error drawn, the probable error being 1. C.—Error of position in an easterly magnetic survey given north and south, and also error of bearing in the vernier-survey, given + or −. D.—Error of position in an easterly vernier-traverse of sixteen sights. E.—Error of position in an easterly magnetic traverse of eight sights out and eight sights back. F.—Error of position in a vernier-traverse of eight sights out and eight sights back. G.—Error of position in a magnetic traverse round a square. G.—Error of position in a square traverse (Class II.).

Mr. I. HODGES thought that Prof. Thompson's paper would give the younger members and students an opportunity of reading for themselves where errors occurred. He understood that in Germany the mine-surveyors used reliable appliances, and that they had to pass examinations of a high standard. He moved a vote of thanks to Prof. Thompson for his interesting and valuable paper.

Mr. W. H. PICKERING, in seconding the resolution, stated that Prof. Thompson's paper had enabled some of the members to step backwards, for 20 or 25 years, to the time when they used surveyors' instruments. He thought that the principal source of error in mine-surveying was the man and not the instrument; but a great point was to take care of the instrument. He agreed with Mr. Hodges that the status of the mine-surveyor ought to be raised; for, at the present moment, the surveyor occupied a rather invidious position.

Prof. G. R. THOMPSON said that what they wanted was that the good and bad results should be carefully observed, to shew what could be done by the instrument under different con-

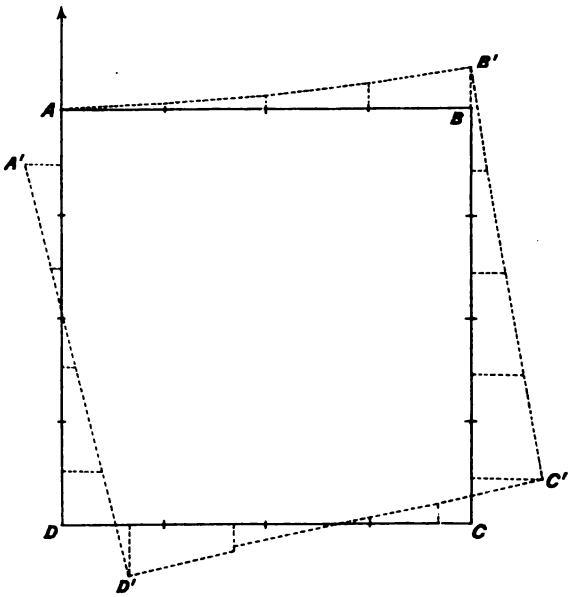
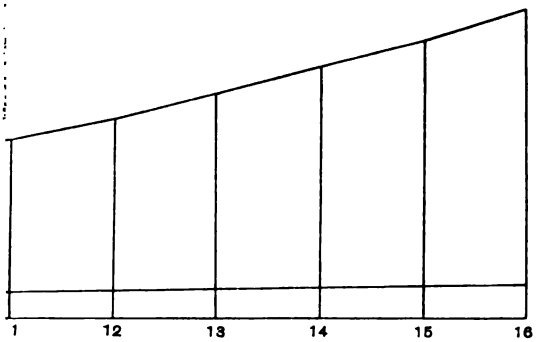


FIG. 8.—PROBABLE ERRORS IN BEARINGS OF A TRAVERSE, ROUND THE SIDES OF A SQUARE, WITH THE THEODOLITE.



, WITH THE

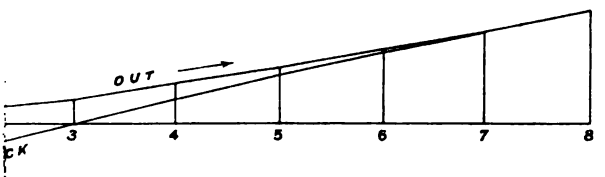


FIG. 7.—PROBABLE ERRORS IN BEARINGS OF AN "OUT AND BACK" TRAVERSE, WITH THE THEODOLITE.

ditions, and whether the error was the result of carelessness, or due to the instrument. The errors in vernier-surveys were not necessarily large:—A 5 inches theodolite would have a probable error of about 12 to 15 seconds, so that it would give a displacement in ½ mile of less than 1 link.

DISCUSSION OF MESSRS. A. H. MEYSEY-THOMPSON AND H. LUPTON'S PAPER ON "SOME OF THE CONSIDERATIONS AFFECTING THE CHOICE OF PUMPING MACHINERY."*

The PRESIDENT (Mr. H. B. Nash) said that his own experience of electrically-driven pumps underground did not coincide with the view expressed by the writers of the paper, so far as the working costs were concerned, for in eight years only one breakdown had occurred with three pumps running daily, the cost in maintenance and repairs being only infinitesimal, when compared with the amount of work done. All were situated 2 miles from the generators, and in his opinion the secret of this successful working was cleanliness, also mains sufficiently large for the current required. There were three other pumps, at an adjoining pit, driven by compressed air, and the useful effect was, in comparison, very low. In each case, the rising mains were large for the amount of water to be pumped. He had also a compound-condensing Hathorn-Davey pumping-engine fixed on the surface, working two sets of 24 inches pumps very efficiently and economically. Another Hathorn-Davey pumping-engine, fixed in the mine, had also given good results; but the valve-gearing had to be replaced with stronger valves than those supplied by the makers of the pumps, before that result was obtained. The cost of maintaining in good order double-beat valves had not been so low as single-beat valves with a leather seating, and if the valves were not accurately fitted, and the water at all corrosive, the valve-faces were eaten away, and required frequent attention at the fitting-shop. He had also had hydraulic pumps, working with a head of water taken out of the rising main, with satisfactory results so long as there was plenty of water for the main pumps; but, with a diminished supply of water, he had found it cheaper to substitute

* *Trans. Inst. M.E.*, 1903, vol. xxiv., page 276; and vol. xxv., page 175.

electrically-driven pumps. Rope-driven pumps, if run at slow speeds, were sometimes usefully applied for dip-workings, where it was inconvenient to take either steam or electricity, but the efficiency was low. The useful effect of steam-driven pumps at the pit-bottom could be considerably increased by running the engine open until fully at work, and then turning the exhaust-steam into the suction-pipe, which acted as a condenser, giving a very considerable vacuum; and he thought that the principle could be more extensively applied with satisfactory results.

Mr. M. H. Habershon said that there was one consideration which he thought should be looked into in determining what type of engine to adopt for pumping large quantities of water, and it was the deciding point in a case he had to deal with a short time ago. An engine was required for lifting 2,800 gallons of water per minute, and it was found that the quantity of air necessary to keep an underground engine-house cool would be so great that it would very seriously interfere with the work that the fan was doing in the ventilation of the mine; as he knew from previous experience that a large quantity of air would be required. In a previous discussion, it was stated that "the consumption of steam at underground pumps must necessarily be high, and their experience pointed to 7 pounds [of steam] per indicated horsepower."* That was obviously a mistake, and he thought that 7 pounds of coal was meant.

Mr. J. R. Wilkinson said that the question of the cost of the power employed in pumping water and for other purposes in and about a mine, was becoming more and more recognized by mining engineers. He was satisfied that more attention could be advantageously given to the class and efficiency of the boilers used. In comparing the work done with the coal burned, it seemed to him that the boiler was quite as important a factor as the engine and pump, and that in comparing the efficiency of pumping-engines with the consumption of fuel, any discrepancy in the performance of the boilers generating the steam should be taken into account. A modern engine fixed on the surface near to the boilers, designed to use high-pressure and the expansive properties of the steam to the lowest

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 180.

possible point, would be an ideal arrangement, and should give good results in the work done for the steam used; but for lifting large volumes of water heavy rods and cumbersome shaft-gearing had to be used, and where the conditions were favourable for an engine at the bottom of the shaft, much could be said in favour of placing it there. The reduced cost, fewer repairs, greater convenience, and less obstruction to ventilation in the shaft, etc., would go a long way towards compensating for the loss in power. He believed that hydraulic pumps were economical, but he had seen a very large shaft-pump that had to be worked in order to provide power for the running of a small hydraulic pump, and in that case it was a costly arrangement. He disagreed with the statement that a disadvantage attendant on electric pumping-plant was its liability to get out of order. Although compressed air was an expensive power, he had seen it do good service in driving pumps fixed long distances underground from the shaft, and he believed it to be a useful mode of power-transmission.

Mr. A. H. MEYSEY-THOMPSON, replying to the discussion, said that their object in writing the paper was to put before colliery-engineers what they generally had difficulty in getting for themselves, namely, the comparative costs of the different systems of pumping. Since they had obtained the results given in their paper, some very useful figures were to hand, relating to the cost of generating current in the various establishments of Messrs. Vickers, Sons and Maxim, Sheffield. The south station, which was the most economical, showed a works cost of 0·469d. per unit generated, while the Moat and Bradley engines, working pumps at the bottom of the shaft by means of rods, built nearly 20 years ago, averaged, during the whole of their recorded life, a cost of 0·22d. per unit, or about half the cost of pumping by means of electrically-driven pumps. The remark in their paper, as to the breakdowns of electrical plant, was taken from a statement by Mr. Longridge (Chairman of the Engine, Boiler and Employers' Liability Insurance Company), and no doubt some breakdowns were due to carelessness. One speaker had referred to double-beat valves as giving trouble, and expressed a preference for single-beat valves. No doubt, in some cases, the latter had much to recommend them, but the

objection was that they did not give the same water-way as double-beat ones, and consequently a larger valve and box had to be provided, and this, when pumping against heavy heads, was a great disadvantage. Valves were the portion of a pumping-plant which turned the makers' hair grey; and it was sometimes necessary with certain waters to adopt valves which under ordinary circumstances would be unsuitable. With regard to condensing, they found that exhausting into the suction was apt to cause trouble, unless provision was made to allow the air carried in suspension in the steam to escape, otherwise it was carried into the pump, and caused it to work unsteadily. The authors did not profess to be skilled electricians, but they thought that the three-phase system had certain advantages, one being that it could carry a higher voltage than the continuous current. In their experience, the cheapest system of all in first cost was the underground engine-pump; next, the overground engine with rods; and next, the electric and hydraulic; both were very expensive, but both had great advantages under certain circumstances.

Mr. H. Lupton said that he fully agreed with what Mr. Wilkinson had said about boilers, but he thought that, in dealing with an engine one ought to eliminate the boilers, as the engineers could not be responsible for the mistakes of the boiler-maker.

About sixty members visited the Thornhill colliery, where, they had the opportunity of witnessing the Craig coal-washer at work.*

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* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 179.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
HELD AT MIDHOPE RESERVOIR, OCTOBER 8TH, 1903.

The members inspected the new waterworks in the Don Valley, namely:—The recently completed Midhope waterworks of the Barnsley Corporation, and the Langsett reservoir, in course of construction, of the Sheffield Corporation.

MIDHOPE RESERVOIR.

In 1894 the Barnsley Corporation, acting on the advice of their engineers, decided to make application to Parliament for powers to construct a reservoir on the Hagg Brook, which is a tributary of the Porter or Little Don river. In 1896, the Royal sanction was given, and in October of that year, the necessary trial-holes were sunk, along the site of the intended embankment, the result shewing that there was every prospect of a watertight foundation being found at moderate depths, in the upper beds of the Millstone Grit and Black Shales. The proportion of the thickness of the grit-stone beds to the shales, so far as the trench disclosed the same, was at the western end, 32 feet of grit-stone in 90 feet of shale; at the eastern end, 14 feet of grit-stone in 114 feet of shale, and near the centre over the bed of the Hagg Brook, the whole was in black shale, except about 2 feet which formed the bed of the brook. The dip of the strata is slightly to the north-east.

The embankment is formed by means of a clay-puddle core, the greatest thickness of which in any part of the trench is 26 feet, and it is battered to the top to a thickness of 8½ feet. Portland-cement concrete was largely employed in forming a cradle for the puddle to rest upon, and in forming walls to protect the clay from the rough rock.

With the exception of the magnitude of the quantities of material used, no special engineering difficulties have been encountered, the site proving to be one of the best that it could have been possible to obtain for the purpose of making a reservoir. The approximate quantities of material used in the embankment were, exclusive of clay-puddle, about 500,000 cubic yards, the clay-puddle amounting to about 40,000 cubic yards.

The height of the top bank of the reservoir above sea-level is 806 feet, and the top water-level is 800 feet. The embankment is about 1,050 feet long, and 145 feet deep from the top of the bank to the greatest depth of the trench. At the bed of the Hagg Brook, the trench was sunk 50 feet.

The discharge-tunnel is through the solid rock at the eastern end of the embankment, and is 6½ feet in diameter of brickwork (in cement) of various thicknesses. The supply for the town of Barnsley is taken through two valves, 30 inches in diameter: the shafts to the valves are in duplicate, each measuring 11 feet by 11 feet by 102 feet deep, and the valves are opened and closed by gearing. It is intended that these valves shall be covered by a house. The embankment has a batter on the inner slopes of 3 to 1, and on the outer slopes of 2½ to 1. The bye-wash has an overflow-sill about 56 feet wide, and is constructed wholly of masonry on concrete-beds in the best possible manner.

The watershed area is about 2,000 acres, and the yield for the purposes of Barnsley and district is about 1,800,000 gallons per day. With the yield from the Ingbirchworth reservoir, this supply is estimated to be sufficient for the needs of the district for the next 40 years.

The filter-beds will be four in number, each 120 feet long by 74 feet wide, and are now being constructed of masonry, concrete and puddle, the filtering-material being broken stone, pebbles, River-trent sand and chalk. The filter-beds will discharge into a pure-water tank, 115 feet by 50 feet, then gauged through a Venturi meter, and passed on to Barnsley. The pressure is broken, on the way, at Wortley, by a covered service-reservoir, which will contain 1,000,000 gallons of water, and is being constructed of brickwork, concrete and puddle. The water-mains are 22 and 20 inches in diameter, and are controlled by valves on the route.

The total expenditure on the works, including the purchase of land, with the works necessary to convey the water to Barnsley, is estimated at £300,000.

The works have been designed and carried out under the supervision of Messrs. T. & C. Hawksley, of Westminster, with the assistance of the late Mr. E. J. Thompson, superintendent of works, and Mr. J. Henry Taylor, resident engineer.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD AT HANLEY, SEPTEMBER 21ST, 1903.

MR. A. M. HENSHAW, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

HONORARY MEMBER—

MR. JOHN CADMAN, H.M. Inspector of Mines, Madeley, Staffordshire.

ASSOCIATES—

MR. R. NIXON, 11, High Street, Brindley Ford, Tunstall.

MR. F. TOMLINSON, Post Office, Vryheid, Natal.

The officers for the ensuing year were nominated.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE GRAND HOTEL, HANLEY, OCTOBER 12TH, 1903.

MR. A. M. HENSHAW, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS—

Mr. D. W. ALLEN, Foundry House, Cobridge, Stoke-upon-Trent.

Mr. R. S. JORDAN, New Zealand Coal and Oil Company, Limited, Kaitangata, Dunedin, New Zealand.

ASSOCIATE MEMBER—

Mr. F. J. MASON, Birchenwood Colliery, Kidsgrove, Stoke-upon-Trent.

ASSOCIATE—

Mr. H. HINDS, 8, Hamilton Road, Hanley.

STUDENTS—

Mr. G. E. HINES, The Hollies, Fenton, Staffordshire.

Mr. GEORGE STEELE, 153, Wheatley Place, Hanley.

The Annual Reports of the Council and of the Finance Committee were read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1902-1903.

The Council have to report that 19 members have been elected during the year:—10 members, 3 associate members, 4 associates and 2 students. Three students have been transferred, 1 as member and 2 as associates.

The following table shows the membership during the past 8 years:—

Year ending.	Life Members.	Honorary Members.	Members.	Associate Members.	Associates.	Students.	Totals.
July 31st, 1896.	1	6	120	3	37	16	183
,, 1897.	1	6	116	5	36	19	183
,, 1898.	1	5	112	4	46	14	182
,, 1899.	1	5	106	5	43	13	173
,, 1900.	1	6	108	4	44	12	175
,, 1901.	0	6	130	9	53	22	220
,, 1902.	0	7	140	10	67	27	251
,, 1903.	0	7	145	11	73	26	262

It may be noted that although 11 members were elected, the net increase is only 5, this being due to 2 having died, 2 leaving the district, and 2 having resigned; of associate members, 3 were elected and 2 resigned, a net increase of 1; of associates 6 were elected and none resigned: and of students, 2 were elected, 1 resigned and 3 transferred, leaving a decrease of 1. The names of three gentlemen appear both as honorary members and members, leaving the net total number at 259, showing a net increase of 11, equal to about 5 per cent.

The Council and members generally deeply regret the deaths of two Past-presidents during the year, namely:—Colonel John Strick, C.B., who died on January 22nd, and Mr. William Heath of Sneyd Colliery, who died on March 30th last. They were among the earliest members of our Institute, both having been elected at the second meeting, held on December 12th, 1872. Their deaths are not only a great loss to the Institute, but to the mining industry of North Staffordshire generally.

During the year general meetings were held in October, December, January, March and May, and excursion-meetings to Keele Boring in October and to Hulton Collieries in June.

The following papers were read during the year:—

"The Gray Type of Safety-lamp." By Mr. James Ashworth.
"Central Condensing-plants for Collieries." By Mr. J. D. Crighton.
"Presidential Address." By Mr. A. M. Henshaw.
"Notes on the Map and Sheet-memoir of the North Staffordshire Coal-field, recently published by the Geological Survey of Great Britain." By Mr. J. T. Stobbs.
"Condensing-plant for Winding-engines." By Mr. B. Woodworth.

These papers, with the discussions upon them and other papers, have rendered the meetings very interesting, and have secured a good attendance of members.

The petition presented to the President of the Board of Education in favour of publishing the recent Geological Survey of the North Staffordshire coal-field on the 6 inches map of the Ordnance Survey has been granted. The work is in hand, and the Ordnance Survey believe that, before the end of 1903, the greater part if not the whole of the maps relating to the North Staffordshire coal-field will be published.

The Fossil Chart of Shells found in the Seams of Coal and Ironstone in North Staffordshire, compiled by Dr. Wheelton

Hind and Mr. J. T. Stobbs, has been published, at considerable cost, by the Institute, and it is hoped that the members and the public generally will show their appreciation of the work by an extensive purchase of this chart.

The members are much indebted to Mrs. John Strick for her generous gift to the Institute of 306 volumes, in memory of her late husband, Col. John Strick, C.B. It is a very valuable addition to our library, comprising as it does many rare and authoritative works, for the reception of which the Council purchased special bookcases, and resolved that they should be denominated "The Strick Bequest."

During the year, 27 volumes have been bound, and the usual exchanges received. The library now contains 790 volumes, which ought to be of great service to the profession, especially to students and workers.

The last session was a most prosperous one for the mining classes conducted on behalf of the County Council in North Staffordshire, with the active co-operation of the members of this Institute. On October 25th, 1902, the prizes were distributed to the successful students by the late Mr. William Heath. The occasion was memorable as being the last public function in which he took part, and the words that he addressed to the students will long be remembered by those present.

Some advance has been made, since the last report of the Council, in the scheme for providing a college for North Staffordshire, in which it is hoped that a permanent home for the Mining Institute will eventually be secured. The site, near Stoke railway-station, purchased by the late Mr. A. S. Bolton for the proposed college, but not transferred at the time of his death, has, through the generosity of Mr. Bolton's family, been secured for the intended purpose, and Mr. F. A. Bolton has taken his father's place as chairman of the Executive Committee. The question of the building and the amount of accommodation required is being dealt with by a committee, on which the Mining Institute is represented, and draft-plans, prepared by Mr. Scrivener, are under consideration. The amount of money raised by the Institute will require to be largely augmented, if we are to contribute to the College funds a sum worthy of the mining industry of the district, and sufficient to do considerably more than merely pay for the accommodation required by the Institute.

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee herewith submit their statement of accounts for the year ending July 31st, 1903.

The total receipts from subscriptions and arrears amounted to £324 5s. 11d., of which £273 6s. 6d. is for current-year subscriptions, leaving £63 16s. 6d. unpaid to July 31st. Of the balance of arrears left over from last account, only £39 6s. has been paid, leaving £105 0s. 6d. unpaid, making a total of £168 17s., the amount of outstanding arrears.

The expenditure has been heavier this last year, owing to a further outlay on the furnishing of the library of £21, and in printing and issuing the *Fossil Chart*, £27. The total amount expended on the library is now £66. This extra expense during the year on account of capital expenditure has, of course, reduced the cash-balance, which stands at £75 19s. 11d. as against £130 2s. 9d. at the end of last year.

The PRESIDENT (Mr. A. M. Henshaw) moved the adoption of the reports.

The resolution was carried.

ELECTION OF OFFICERS, 1903-1904.

The SCRUTINEERS reported the following appointments:—

PRESIDENT:
Mr. A. M. HENSHAW.

VICE-PRESIDENTS:

Mr. G. P. HYSLOP.	Mr. G. A. MITCHESON.	Mr. JOHN NEWTON.

TREASURER:
Mr. THOMAS ASHWORTH.

SECRETARY:
Mr. F. R. ATKINSON.

COUNCILLORS:

Mr. JOHN CADMAN.	Mr. A. HASSAM.	Mr. G. A. MILLWARD.
Mr. G. W. COWLISHAW.	Mr. G. E. LAWTON.	Mr. THOMAS ROBERTS.
Mr. G. H. GREATBACH.	Mr. JAMES LOCKETT.	Mr. W. STATHAM.
Mr. JOHN GREGORY.	Mr. J. MADDOCK.	Mr. J. T. STOBBS.

The PRESIDENT (Mr. A. M. Henshaw) delivered the following address:—

PRESIDENTIAL ADDRESS.

By A. M. HENSHAW.

I have to thank you, gentlemen, for the honour that you have again conferred upon me by electing me to the presidential chair for another year.

It seems so recently that I addressed you in a somewhat lengthy, and I fear tedious, fashion upon the present position of our steel, iron and coal-trades with relation to other countries, that I purpose on the present occasion to confine myself briefly to another element in the question of our commercial and industrial progress, which I think has a more personal bearing for members of an institution of mining and mechanical engineers.

Very serious questions relating to our commercial power as a nation are exercising our minds at the present moment, questions so closely affecting our individual prosperity and the domestic economy of the country, that we find ourselves involved in the turmoil of political, commercial and financial controversy. This is not the time, however, nor is it the place, to enter upon political problems. They are not the only serious questions. There is another, equally important to us and intimately connected with our national progress, which I would make the topic of my remarks to-day. I mean the individual responsibility of those charged with the control of the great industries of this country in regard to the efficient training and education of the leaders of industry, and more particularly those engaged in one which has held in the past and must hold in the future, a leading place in the national vitality—the industry of mining.

By reason of international competition, increasing natural difficulties, and rapid strides in mechanical and scientific processes during recent years, no profession has required more strenuous effort than that of the mining engineer. In no profession is there greater need to-day for men of technical skill, scientific attainments, determination and resource; nor in any

commercial enterprise are the results, as between indifferent and conspicuous ability on the part of the management, more definite and far-reaching.

It may, to some extent, be attributable to the limitations of our natural resources that we have lost our place as the largest producer of coal in the world; but whatever the cause, whether we are crippled by shorter hours of labour, trades-union regulations, transport-difficulties, bounties and subsidies, the dumping of surplus foreign products, or legitimate competition, we have the results before us. We have the industrial war to fight, and our equipment must be thorough and sound.

In this struggle, gentlemen, a higher standard of education, technical, scientific and commercial, will be our best weapon and most invulnerable armour. It is then a source of considerable satisfaction to find that the provision of facilities for such education is now receiving more serious attention throughout the country. So far back as 20 years ago, the subject of technical education was considered by a Royal Commission with little result; our great universities have scarcely moved; but other governing bodies have taken the matter vigorously in hand, as is evidenced by the great Technical Schools of Manchester, Birmingham, Sheffield, Bristol, Leeds, Wigan, and others. It is education, gentlemen, with all that the word implies, that builds up the character of a nation, and we must apply it to our business and commerce to the fullest extent. Yet we learn that out of a population of 41,000,000 we have only 25,500 university or university-college students, or 6·22 to each 10,000 inhabitants: whereas the United States with 76,000,000 population have 97,100 students, or 12·76 per 10,000; and Germany 7·87 per 10,000; while the amount contributed by private individuals in the United States for higher education is eight times greater, and in Germany six times greater than in the United Kingdom.

The teaching of mining as a special science is every year being accomplished in a more satisfactory and practical manner at our university colleges, mining schools and evening classes, affording opportunities at one or other for the proper training of the student as well as the more advanced and responsible worker. It should be the special care of the Mining Institutions to see that no effort is spared to promote such facilities not only for the student, but for the manager who must ever be a student

if he would keep pace with the advancing times and the higher standard of efficiency which success entails.

The education of a mining or engineering student should begin at an early age. His profession should be decided upon as soon as his natural inclination asserts itself, and at the higher-grade school his future career will be greatly assisted by a good groundwork in practical mathematics, physical science and chemistry, which should be made interesting by laboratory-practice, supplemented by the use of simple tools and the teaching of craftmanship; and it is greatly to the credit of our professors that really practical mathematics are now being taught in our schools. The science-subjects of the curriculum are too often treated superficially as mere polish, much as accomplishments are taught at a young ladies' boarding-school. The student should not be crammed for the purposes of examination, and in the advanced stages, if the teaching be too academic there is a danger of raising doubts in his mind as to the practical value of much that he learns. The student must be led to realize that he is learning to think, and as he advances the application will amount to intuition. He must not imagine that his theoretical training ends where the practical begins, for the training should be as practical as possible throughout, with the business and commercial aspect progressively kept before his mind. If after such preparation, at say the age of 16, he is found to possess a mechanical turn of mind, has plenty of common-sense, faculty for plodding, fondness for study, a sturdy constitution, and, I might add, the instincts of an honest man and a gentleman, you have the material necessary for the making of a successful man who will uphold the best traditions of his profession.

His next stage is a most important one, opinions being somewhat at variance as to whether he should now take a college-course or be at once put to practical work. Now, in no profession, in my opinion, is early practical knowledge more necessary than in mining, and while each is essential, theory and practice must go together, so that work and study should run concurrently. If college-training is decided upon, I would first give the student 12 months practical work at a colliery, whilst he is young enough to delight in the new experience of

life underground, feeling no false shame in his ignorance, or afraid to ask questions from anyone. He will acquire a rough knowledge of the general operations, and store his mind with little things which at a more mature age would escape his notice, or that he would perhaps then consider beneath it. He will learn to understand and appreciate the object and application of his subsequent studies.

His college-course following should extend to at least three years, but with a view to thorough efficiency there should be breaks or intervals spent at a colliery or works, with frequent visits to works during the college-term for the purpose of studying the practical side of the subject upon which he is working. I cannot insist too strongly on the importance of practical work for the mining student, who will never become a great leader without intimate practical knowledge, with its accompanying power of influence over his men in after-years. Confidence, with a knowledge of human nature, cannot be taught by books and schools: this will only come by close contact with workmen and their work. It is, however, equally certain that practical as he may become, he will never rise to high rank in his profession without the brain-development which is alone acquired by systematic scientific study.

In connection with college-training, which is only within the reach of a few, by reason of expense or distance from home or place of employment, there is under the present system a great danger that the student will lose touch with practical and commercial affairs at the mine, and it is much to be desired that schools of mines should be established in the centres of the industry. This want is being splendidly met by our excellent evening classes, and in North Staffordshire we hope shortly to have our own technical college and mining-school. It is greatly to the credit of this Institute that we are giving the scheme our active and practical support.

Our County Council classes and those of the Board of Education are invaluable, and I am convinced are destined to do even better work. They open the way for students to attain to positions as colliery managers, and to earn scholarships, admitting them if they choose to the university-colleges. Some of our most brilliant young men have received their training in this way. They possess this great advantage that the

student may take regular employment while pursuing his studies at evening classes, and I am inclined to give preference to the plan of apprenticing a young man to a mining engineer at a colliery, where, if full advantage is taken of technical schools and mining classes he may come out as well as, if not better than, the college-student: indeed he lacks nothing in the shape of opportunity for special education to qualify him for the highest positions.

Do our young men take full advantage of these opportunities? I fear not, and I would with all the insistence at my command impress upon them the necessity of such study if they would reap the reward in store; for, without doubt, the industrial value of scientific and technical knowledge is now so widely recognized by employers, that there has never been so bright an outlook for well-trained and well-educated young men.

I would also urge upon the student the importance of attaching himself to one of the societies associated with The Institution of Mining Engineers, where he will come into contact with older men, and make useful friends, who will be always ready with mature advice and encouragement. He will there find a new interest in being in touch with advanced practice in his calling, securing, too, some of the best modern literature in the *Transactions*. Our Mining Institutes, with their libraries, facilities for intercourse, and papers and discussions on up-to-date practice by the most competent authorities, occupy an important position as an educational factor.

And now, just a word in this connection as to the position of the mining engineer and colliery manager, who, as I said just now, must ever be a student.

Many years ago, before the necessity of education was felt so keenly, a few self-taught men, by their native ability, recorded their names and their work prominently in the annals of our industrial history. All honour to those men, but now the conditions are vastly different, and positions of eminence are only for those of intellectual superiority and high education. The pursuit and constant study of scientific progress is the only key to success for the mining man to-day. And, to be successful, it is not only essential that he should himself be expert, but he must surround himself with a carefully-selected and organized

staff of educated and trained assistants, each specially well up in modern methods as applied to his particular work; men deserving and capable of taking their full share of responsibility and control in their different departments; men who will be encouraged to initiate, and whose resourcefulness he will be quick to recognize and amply reward.

Organization must be assisted by a complete and accurate system of routine, with a record of results and costs for each producing and spending department, showing at a glance the contribution of each to the total result: abstracts from these figures being given to each responsible official in such form as to secure his interest and co-operation in setting up standards of efficiency and economy.

The tendency of the times is in the direction of specialization, and I should be glad to see regulations brought into force requiring that every subordinate official shall hold some grade of certificate of competency.

In no respect, perhaps, has science come to the aid of mining more conspicuously than in the devising and application of mechanical power, and time- and labour-saving machinery, now so necessary in each process, from the getting of the coal at the face to the preparation of it, or its products, for the market; and it is too often, I fear, due to the lack of knowledge or study of such modern means and want of their judicious adoption that the mining man sometimes fails to achieve success. It is absolutely essential that every move should be closely followed, and every promising improvement or advantage carefully considered.

In the stress of hard times and keen competition before us, it will be the best educated man who will be found at the front, and it is by this means that the position of the mining engineer is being raised to one of the highest in the world of scientific and skilled industry. The commercial status of this country in no small measure depends upon our good stewardship of the wealth of our coalfields; £120,000,000 of capital, the lives of 900,000 men, and the daily bread of 4,000,000 fellow-creatures are in our hands, every day bringing more onerous burdens upon us, and more stringent demands for the intellectual fulfilment of our responsibilities. It is the serious duty of this Institution to further the cause of higher scientific and technical education,

and our duty as members to acquire for ourselves the power which only by a higher degree of education is attainable, so that, realizing (as we must do) the weight of the moral and financial obligations laid upon us, we may the better discharge our trust.

Mr. W. N. Atkinson remarked that the members would all agree with Mr. Henshaw's remarks as to the necessity for increased scientific and technical education. From the interest that the Institute had taken in the question in the past, there was no doubt that the members were quite alive to the necessity of attention being paid to the subject. They might congratulate themselves on again having Mr. Henshaw as their President, seeing that much of the successful working of the Institute during the past year had been owing to his initiative. He had pleasure in moving a vote of thanks to the President for his valuable address.

The vote was approved, and was briefly acknowledged.

Mr. John Cadman read the following paper on "The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field":—

THE OCCURRENCE, MODE OF WORKING, AND TREATMENT OF THE IRONSTONES FOUND IN THE NORTH STAFFORDSHIRE COAL-FIELD.*

By JOHN CADMAN, M.Sc., F.G.S.

Part II.—Clayband Ironstones.

I.—*Bibliography.*

Part I. contains a list of papers already published on the subject of the ironstones of North Staffordshire, and the following references may be added to that list:—

"Iron-ores Committee: Special Reports: North Staffordshire." By **Messrs.** R. Heath and J. C. Homer. *Journal of the Iron and Steel Institute*, **1871**, vol. ii., page 1.

Coal-fields of Great Britain. By Dr. Edward Hull, 1873, third edition, page 176; and 1881, fourth edition, page 187.

Metallurgy: Iron and Steel. By Dr. John Percy, 1864, page 202.

II.—*Introduction.*

The working of clayband ironstones in North Staffordshire has now practically ceased, owing to the high cost of working and the introduction of imported ores from localities where open-cast work exists. It is not surprising that these ironstones, occurring intermixed with bands of shale and clay, lying at variable inclinations, in a highly faulted coal-field, should perforce remain unworked in order to give way to a cheaper ore, frequently of better quality.

These ironstones have so largely contributed to the prosperity of the iron-trade in this country, that the discontinuance of their use and the fact that heavy raw material is being imported and finished iron and steel exported, cannot but make one ponder very seriously on the ultimate issue of the iron-industry of this district.

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 89; and vol. xxiii., page 50.

The writer wishes to record some details of this class of ironstone, taken chiefly from his own observations in the west of the coal-field, where the various seams are well developed, the physical conditions favourable to ironstone-working, and, in consequence, the seams have been worked later than elsewhere.

Under the head of clayband, are included certain ironstones which are in reality semi-blackbands, such as the Burnwood or Little-mine—this semi-blackband characteristic is, however, only a local condition.

Clayband ironstones are amorphous argillaceous carbonates of iron, having a compact clay-like appearance, and occurring in layers of more or less regular nodules enclosed in beds of shale and clay. They occasionally coalesce into beds, which, however, are seldom of any considerable extent or thickness.

III.—*History.*

The clayband ironstones of North Staffordshire have been worked from a very early period. Dr. Plot, in 1686, referred at some length to the ironstones of this district in a passage which the writer has already transcribed in Part I.*

About 1769, when Pitt, Earl of Chatham, contemplated an addition to the national revenue by a tax on coal at the pit-mouth, statistics were produced showing the number of furnaces then in blast, from which it was seen that there were 2 furnaces at work in North Staffordshire, namely:—Apedale, with 1 furnace producing 728 tons 10 cwts. per annum, and Silverdale with 1 furnace producing 1,230 tons per annum. The average output per furnace in England and Wales at that time, was stated to be 1,048 tons per annum. Statistics taken thirty years previously showed an annual output per furnace of 294 tons per annum.†

Table I. contains a list of the furnaces in North Staffordshire in 1839, producing each 50 tons of pig-iron per week or annually 18,200 tons.‡ These furnaces would be working chiefly, if not entirely, on clayband ironstone.

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 91.

† *History of the Iron Trade*, etc., 1854, by Mr. Harry Scrivenor, page 57.

‡ *Papers on Iron and Steel*, 1840, by David Mushet, page 418.

TABLE I.—FURNACES IN NORTH STAFFORDSHIRE IN 1839.

Proprietors.	Name of Works.	Furnaces.		
		In Blast.	Not in Blast.	Building.
Thomas Firmstone	Apedale	2	1	..
W. Sparrow & Co.	Lane End	2	—	—
Thornborrow & Co.	Fenton Park	2	..	..
Earl Granville	Skelton	—	..	3
Thomas Kinnersley	Lawton	1	—	—
W. Sneyd	Silverdale	—	2	—
Totals		7	3	3

IV.—*Geology.*

The clayband ironstones predominate in the Middle Coal-measures, occupying a position between the Bassey-mine coal-seam and the Ash coal-seam. The following is a general section of the ironstone-seams as they occur in the west of the field. The writer does not propose to attempt to correlate the seams in this section with other parts of the district. Excellent work has, however, been done on this subject by Mr. John T. Stobbs, although much remains to be affected.

TABLE II.—GENERAL SECTION OF THE IRONSTONE-SEAMS IN THE WESTERN FIELD.

	Feet.		Feet.
Base of Blackband series	—	Strata	31
Strata	324	8 New-mine Ironstone	—
1 Black-bass Ironstone	—	Strata	69
2 Cannel-mine Ironstone	—	9 Brown-mine Ironstone	—
Strata	63	Strata	120
3 Gubbin-mine Ironstone	—	10 Thick-band Ironstone	—
Strata	21	Strata	63
4 Sheath-mine Ironstone	—	11 Gold-mine Ironstone	—
5 Black-stone Ironstone	—	Strata	60
Strata	42	Ash Coal-seam	—
5 Rusty-mine Ironstone	—	Base of Middle-Coal measures	
Strata	57	Strata	114
6 Chalky-mine Ironstone	—	12 Burnwood Ironstone	—
Strata	39	Strata	825
7 Little-mine Ironstone	—	13 Top Two-row Ironstone	—

Physical Characters.—The clayband seams all possess a close resemblance to one another, occurring in bands and irregular nodules (called by the miners "chance bands") which are often concretionary.

The ironstone is compact and free from lamination, with the exception of the "semi-blackband" variety, which shows bed-

ding in the form of layers of carbonaceous shale. It is compact in structure, very fine-grained, and extremely hard, being much harder than blackband ironstone. The specific gravity varies from 2 to 3·9. The stone is of a bluish-grey colour, which, on exposure to the atmosphere, oxidizes to a greyish-brown. The streak is light-grey and the fracture sub-conchoidal.

Joints.—Jointing does not occur so well developed and to the same extent as in the blackband seams, and the parallelism between the joints is not so well defined. Cross-jointing is rare, and, when it does occur, is very irregular. Joints in a band of stone are spaced from 3 to 12 inches apart, and do not as a rule pass into the adjacent shale. The shale that intervenes between the ironstone-bands, however, exhibits joints, which frequently run in a different direction from those occurring in the stone.

The larger nodules and bands are often divided into irregular cracks or small fissures, analogous to those produced by clay in drying: and they are usually filled with hydrated silicate of alumina or carbonate of lime, containing minute crystals of blende, galena, and iron-pyrites. The jointing varies in distance in direct ratio to the thickness of the band.

V.—*Palæontology.*

The fossil fauna and flora of this group of ironstones is very extensive, and has been fully dealt with in an excellent paper by Mr. John Ward.*

VI.—*Clayband Ironstone-seams.*

The following are typical sections with a few notes on each seam.

Black-bass Ironstone.—The section at Apedale is as follows:—

	Ft.	In.		Ft.	In.
Shale	—		Shale	1	3
IRONSTONE ... 3 inches to	0	6	IRONSTONE	0	1
Shale or bass	—		Shale with nodules of ironstone	1	4
IRONSTONE	0	1	IRONSTONE	0	2½
Shale	0	3	Shale ... ... 1 foot to	2	3
IRONSTONE	0	2			

* *Transactions of the North Staffordshire Institute of Mining and Mechanical Engineers*, 1890, vol. x.

This seam has not been worked to any great extent, and where worked it was removed from the top of the goaf of the cannel-mine seam, the holing being made in the goaf. The thickness of the working was about 7 feet, and produced from 9 to 15 inches of ironstone.

Cannel-mine Ironstone.—A section at Bassiloes is as follows:—

	Ft.	In.
Black-bass	—	
IRONSTONE, Top Band or Grit	0	10
Shale or bass	1	0
IRONSTONE, Flannel ...	0	2½
Shale or bass	0	2
IRONSTONE, Whet-stone ..	0	4
Shale or bass	1	0
IRONSTONE, Brown-band ...	0	2
Shale or bass	1	0
IRONSTONE, Blue-band, 5 inches to	0	8
Bass, with chance bands of *ironstone*	3	0
Cannel-mine Coal-seam	—	

This seam is usually worked in conjunction with the Cannel-mine coal-seam. In rearer mines, the coal is removed by retreating longwall, and when the gob is "slipped," it is turned over and the ironstone is picked out. When the seam is lying at a low inclination, the ironstone-roof, after being allowed to fall in the waste, is turned over, and the ironstone picked out. At Apedale, where a thickness of some 20 feet of bass intervenes between the coal and the stone, the ironstone was worked satisfactorily by longwall on the top of the goaf of the Cannel-mine coal-seam, small cruts being driven to recover the seam from the levels in the Cannel-mine coal-seam, at intervals of 90 feet. With this exception, the method of working is somewhat unsystematic. The seam is very variable in quality and thickness.

Gubbin-mine Ironstone.—The section at Hollywood is as follows:—

	Ft.	In.
Hard shale	1	0
IRONSTONE	0	3
Grey shale, roof	1	2
IRONSTONE, Lean	1	1
Bass	0	1
IRONSTONE	0	11
Fire-clay	1	3
Hard fire-clay, floor	—	

This seam has not been worked extensively, the lean ironstone-band being frequently very inferior. It was worked by longwall, with the face on the line of strike, sladders being formed at intervals of 75 feet. The holing was made in the fire-clay, water being thrown in to soften it. The goaf of this seam was unable to hold all the dirt-refuse existing between the bands

of ironstone, necessitating the removal of a considerable quantity out of the mine.

Sheath-mine Ironstone.—The section at Kents Lane is as follows:—

	Ft.	In.		Ft.	In.
Hard black shale, roof	—		**IRONSTONE**	0	3
IRONSTONE	0	3	Grey shale	0	8
Grey shale	0	2	**IRONSTONE** 6 inches to	0	4
IRONSTONE, Lean	0	11	Fire-clay	3	4
Grey shale	0	2	Black-stone Ironstone-seam ...	—	

This seam has been extensively worked of a working thickness of 6 feet, containing from 1½ to 2 feet of ironstone. It is of a very irregular nature, and frequently requires a considerable quantity of refuse to be sent out of the working-faces.

Black-stone Ironstone.—The section at Kents Lane is as follows:—

	Ft.	In.		Ft.	In.
IRONSTONE	0	3	**IRONSTONE**	0	2
Black shale or bass	0	6	Black shale	0	2
IRONSTONE	0	2	**IRONSTONE**	0	6
Black shale	0	5	Fire-clay	—	

This seam has not been much worked, lying as it does immediately contigous to and to 8 feet beneath the Sheath-mine. Where worked, the Sheath-mine was of an inferior character, and was left as a roof.

Rusty-mine Ironstone.—This seam has been very little worked on the west of the coal-field. The joints of this seam are filled with a deposit of hydrated oxide of iron, which imparts to the ironstone a rusty appearance. The Pennystone ironstone of the eastern side lies about the horizon of the Rusty-mine, and has been much worked.

Chalky-mine Ironstone.—The section at Hollywood is as follows:—

	Ft.	In.		Ft.	In.
IRONSTONE	0	4	**IRONSTONE**, Hussle-band ...	0	5
Black shale, roof	3	0	Black shale	0	3
Black shale with chance bands of *ironstone*	1	1	**IRONSTONE**, Lean	0	9
			Coal	2	0

This seam has been very extensively worked. The coal underlying the seam makes an excellent holing, and some of it is sent

out of the mine for use in calcining the ironstone. The lower lean band of ironstone frequently presents a semi-blackband appearance, but the upper bands remain unaltered. The goaf of this seam holds the greater part of its own refuse, and very little requires to be sent to bank.

The joints in this ironstone are filled with abundant depositions of carbonate of lime, giving the seam a characteristic white appearance from which it has derived its name.

Below the Chalky-mine, at Tunstall, Mr. Walcot Gibson discovered a spherulitic carbonate of iron containing 41·33 per cent. of iron in the calcined stone.* This band has not, however, been observed on the western side of the coal-field.

Little-mine Ironstone.—The section at Kents Lane is as follows:—

	Ft.	In.		Ft	In.
Black shale or bass, roof	—		**IRONSTONE**	0	3
Nodules of *ironstone* 1 inch to	0	3½	Black shale	0	2
Black shale	1	10	**IRONSTONE**	0	3
IRONSTONE, Lean	0	10	Hard dark shale, floor	—	
Shale	0	3			

This seam has not been worked very extensively, and when worked, the longwall-face coincided with the line of strike.

New-mine Ironstone.—The section at Kents Lane is as follows:—

	Ft.	In.		Ft.	In.
Bass, containing nodules of *ironstone*, roof	—		**IRONSTONE**	0	9
Black shale or bass	1	1	Coal...	0	5
Slickensided shale	0	4	Fire-clay	0	4
			Hard grey shale, floor	—	

This seam has been worked on the longwall system, the holing being made in the lower fireclay and coal. During working, a considerable amount of shale had to be sent to bank, after the goaf had been packed solid. The coal, underlying this seam, frequently becomes a carbonaceous shale and sometimes cannel.

Brown-mine Ironstone.—The section at Kents Lane is as follows:—

	Ft.	In		Ft.	In.
Coal	4	0	Bass	0	5
Bass	3	0	**IRONSTONE**, Black-stone ...	0	8
IRONSTONE	0	8	Bass	0	6
Bass	0	6	**IRONSTONE** ... 4 inches to	0	8
IRONSTONE	0	3			

* *Memoirs of the Geological Survey: Summary of Progress of the Geological Survey of the United Kingdom*, 1899, page 108.

This seam has been very extensively worked. The coal, lying above, being of inferior quality, is left up and makes an excellent roof. Longwall working is carried on to the rise, the line of face being formed at an angle of 10 degrees with the line of strike. Sladders or shoots are made at intervals of every 75 or 90 feet by pack-walls, the roof of which is ripped into the coal as shrinkage takes place.

These sladders stand remarkably well, and enable long lengths of the seam to be worked to each level. The holing is made immediately below the top-band of ironstone, the lower portion being removed by blasting. The lower bands of this seam frequently occur as a semi-blackband.

Thick-band Ironstone.—This seam has not been worked, with the exception of an isolated area.

Gold-mine Ironstone.—The section at Hollywood is as follows:—

	Ft.	In.
Black shale, with chance bands of *ironstone*	—	
Grey shale	1	3
IRONSTONE	0	4
Grey shale, with nodules of *ironstone*	1	0
IRONSTONE	0	8
Grey shale	0	6

This seam varies very considerably in thickness and quality. It is opened out somewhat differently from the other clayband seams, inasmuch as the longwall-face is formed from pillars, left to support the working-level. The roof contains numerous slips and joints, and requires considerable support. The goaf is entirely filled with the shale, and considerable quantities have to be removed from the pit. The floor of this seam, being above a considerable thickness of carbonaceous shales, gives off fire-damp.

Burnwood Ironstone.—This seam is much worked on the eastern side of the coal-field, and is known by the name of Little-mine ironstone near Fenton. It is a semi-blackband, and has the following section:

Chell District.	Ft	In.
Bass, roof	—	
IRONSTONE	2	4
Press shale	2 inches to	1 6
IRONSTONE	1	5
Coal	0	8
Fenton District.		
Bass, roof	—	
IRONSTONE	0	4
Bass	0	8
IRONSTONE, Chance	0	3
Bass	0	3
IRONSTONE, Lean	0	6
Bass	0	6
IRONSTONE, Chance	0	3
Bass	0	4
Coal	2	4

Top Two-row Ironstone.—The section at Silverdale is as follows:—

	Ft.	In.		Ft.	In.
IRONSTONE, containing *Carbonicola*	3	6	Bass	0	8
Bass, with chance bands... ...	2	0	**IRONSTONE**	0	4
IRONSTONE	0	3	Bass	1	6
			Top Two-row Coal-seam	2	6

This seam has not been worked systematically, but when the bands of stone were good, it was worked together with the Two-row coal-seam.

VII.—*Analyses.*

Table III. contains analyses of samples of ironstone from Silverdale, taken from the workings described in the foregoing part of this paper.

TABLE III.—ANALYSES OF CLAYBAND IRONSTONES.

Name of Mine ..	Kents Lane.				Hollywood.				Nabbs.
Name of Ironstone-seam	Cannel-mine.		Sheath-mine.	Chalky-mine.	Chalky-mine.		Brown-mine.	Gold-mine.	Top Two-row.
	Tops.	Bottoms		Tops.	Bottoms	Bottoms			
Loss on ignition	39·91	32·87	37·84	32·51	29·15	29·29	33·84	35·60	30·36
Silica	14·30	29·00	5·00	22·46	34·95	23·50	13·80	16·56	31·00
Alumina... ...	0·33	3·03	2·00	0·20	0·43	1·70	0·60	0·84	3·00
Ferrous oxide ..	34·65	25·88	44·03	39·70	29·24	36·81	41·15	34·87	26·34
Ferric oxide ..	1·60	0·58	1·11	0·80	0·87	1·77	1·84	2·15	0·40
Manganese oxide	2·20	2·10	2·92	1·00	0·89	1 93	1·40	2·39	2·69
Lime	3·70	3·40	3·67	1·61	2·28	2·33	4·00	4·39	3·11
Magnesia ...	2·88	1·83	2·80	0·60	2·66	1·70	1·65	2·70	1·79
Phosphoric acid	1·02	0·75	0·69	0·67	0·51	0 44	1·82	0·97	0·63
Sulphuric acid ...	0·46	0·27	0·50	0·17	---	0·49	0·31	Trace	0·47
	101 05	99·71	100·56	99·72	100·98	99·96	100·41	100·47	99·79
Metallic iron ...	28·07	20·32	35·03	31·44	23·35	29·86	33·29	28·63	20·77

VIII.—*Methods of Working.*

The mines are leased on royalties varying from 6d. to 1s. per ton, calculated on the calcined ironstone.

The relative order in which these ironstones are worked is a matter which has received very little consideration: the order of working being entirely subservient to the quality of the seam and cost of working.

The clayband seams on the west side of the coal-field lie at steep inclinations, and with very few exceptions are all worked

on one general system, namely, longwall to the rise: the line of face coinciding with the line of strike, or nearly so, the exact position being determined by the jointing. The workings are set out as shown in Fig. 1: a series of shoots or sladders being constructed at intervals of 60 to 90 feet, down which the ironstone is thrown, after being picked and cleaned at the face. This operation is termed "bowling." The ironstone falls to the bottom of the sladder, where it is loaded into wagons. At the bottom of the sladder, a wooden battery is built, to prevent the ironstone from falling into the level. The stone is loaded from the side of the battery, provision being made for the placing of the wagon.

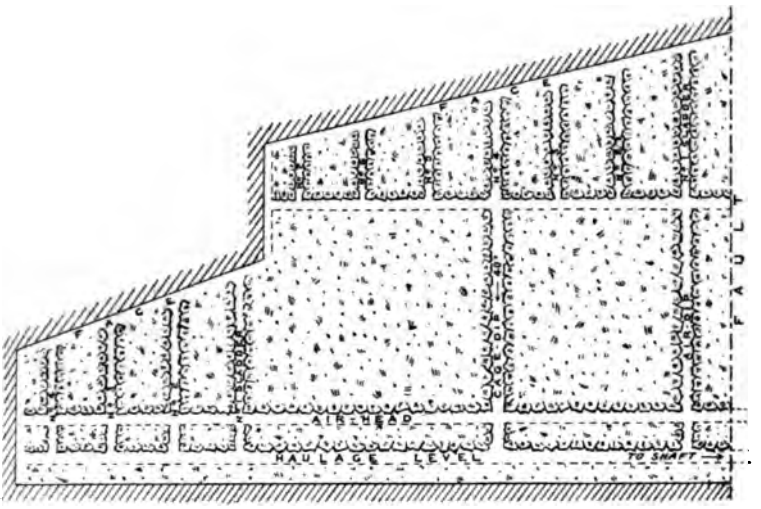

FIG. 1.—PLAN OF WORKINGS. SCALE, 270 FEET TO 1 INCH.

The sladders are made by building pack-walls on either side with the strongest shale procurable; and where the roof requires timber, recesses are left in the pack-walls for their support. Frequently the floors of the sladders are paved with hard shale; and plates of sheet-iron are fixed on the floor, where any sluggishness of slipping occurs. As the face advances, the sladders become longer, cross-levels are then made at intervals of 240 to 360 feet, cutting off the old sladders, the distance being dependent upon the conditions of the seam.

The operations at the face are conducted by the miner standing on a floor, composed of débris packed into the goaf. Wagons

are raised and lowered by gravitation from the various levels by means of cage-dips.*

Owing to the large amount of débris produced, the goaf is always packed solid, and the pack-walls are kept close to the face. This system ensures good roof-support and, consequently, the timber-expense is not heavy.

Machine-cutting has been successfully introduced into clay-band seams, such as the Burnwood, working at low inclinations.

Tools.—The tools used in the working of this class of ironstone are identical with those used in the blackband seams, and described in Part I. From 7 to 12 tons of ironstone are produced per pound of gunpowder. This figure is taken from the working of the Brown-mine and Chalky-mine seams lying at angles of about 40 degrees. The quantity of explosive per ton increases as the inclination decreases.

Timbering.—The usual methods of roof-support are adopted, but owing to the goaf being so closely packed, heavy timber is not necessary. Spragging, at the working-face, is of the utmost importance, and must be carried out with the greatest care and in the most systematic manner, owing to the irregularity of the jointing.

Labour.—A longwall-face is divided into sections, the length of which is fixed according to the distance apart of the sladders, and worked by a set of men, consisting of 3 colliers, who get, clean and throw the ironstone into the sladders, at a charter-price per ton, which includes all timbering at the face, packing and building the sladder, cost of explosives, tool-sharpening and lights, where candles are used. Each set of men has the use of one sladder, which forms a storage for their ironstone.

Loading, from the bottom of the sladder, is done by fillers or loaders, at a price per ton. They load from 5 or 6 sladders, that being about the number open at each level.

The general conditions of haulage and datal-labour, etc., are similar to those described in working the blackband-seams.

IX.—*Calcination of the Ironstone.*

The ironstone, after being sent out of the mine, is sometimes allowed to weather, being left to the action of the air for some

* "Notes on Rearer Workings." By the Author. *Trans. Inst. M.E.*, 1897, vol. xiv., page 392.

time. Superficial oxidation disintegrates the shale, which can then be readily removed from the iron-stone. It is however usually clean enough to be *rucked* immediately, for calcination.

The process of rucking differs slightly from the method adopted in rucking blackband ironstone, for the ironstone containing very little carbonaceous matter (if any) has to be mixed with fuel in order to roast it. The rucks are built of trapezoidal shape, of similar dimensions to the blackband ruck; with the exception that they are made considerably higher, say, about 8 feet, which after calcination falls to 6 feet 3 inches.

The floor of the ruck is prepared with a depth of 9 inches of coal, called "bottoming," upon which the ironstone is tipped from an embankment. The wagons containing the ironstone are brought over the top of the ruck and tipped over the face, as contrasted with the blackband system of rucking on the face.*

The ironstone is mixed with from 3 to 4 per cent. of fine coal during rucking, the small coal being scattered among the stone. All large pieces of stone are broken. The rucks are "shored" with small stones and coal, and are lighted by small fires set along the base of one end of the ruck.

The process of "knobbling" or "fettling" is carried on, as with the blackband ironstones, but does not require so much skill and attention. The progress of the fire is regulated by throwing small mine-dust on the line of fire. The chief object of the knobbler is to prevent overburning, which makes the calcined ironstone very hard and difficult to remove from the calcined ruck.

After calcination, this ironstone is called "lean mine," and is loaded direct for the blast-furnace, no separation into different grades of quality being necessary.

Fig. 2 shows how loading is commenced from a newly calcined ruck. When the ironstone has been overburnt, it becomes very hard and difficult to remove from the ruck: this is, however, overcome by means of the "swaying bar," composed of a bar of steel or a railway-rail, from 9 to 12 feet long, which is fixed under the portion to be removed. Blocks of wood or pieces of iron are used as a fulcrum, and a plank is then placed on the outside end of the bar, upon which some 4 to 6 men stand. By

* Semi-blackband ironstones are, however, rucked in the same way as blackband ironstones.

swinging their bodies from the knees, they bring pressure to bear upon the bar, Fig 3, which breaks down the hardened face. The mine is then broken into sizes requisite for the blast-furnace by means of hammers and bars.

The loss in weight, during calcination of clayband-ores, varies considerably with the different qualities of ironstone, and from 18 to 20 per cent. may be taken as an average loss.

FIG. 2.—LOADING CALCINED LEAN-MINE.

The cost of producing calcined clayband ironstone may be stated to vary from 10s. 6d. to 13s. per ton. In the discussion of some "Observations on the Clayband Ironstone or 'Mine' of the Northern Outcrop of the South Wales Coal-field," Mr. Edward Williams stated that there was not any great prospect of bringing Welsh mine again into use, even at the low price of 11s. per ton.* Just as in South Wales, so in North Staffordshire, the use of this class of ironstone has been abandoned, in order to make way for cheaper imported iron-ores.

The following statistics, taken from Government returns,

* *Transactions of the South Wales Institute of Engineers*, 1881, vol. xii., page 384.

over a period of about 30 years, show the output of ironstone from North Staffordshire.

Year.	Tons.	Year.	Tons.
1874	2,575,844	1894	828,856
1884	1,783,800	1902	776,363

These figures include the output of both clayband and black-band ironstones and show a most serious decrease in what was once a very important branch of the mining industry of North Staffordshire. There does not appear to be much prospect of the clayband ironstones becoming of commercial value again, until such time as the cheaper foreign ores are exhausted.

FIG. 3.—"SWAYING."

The PRESIDENT said that Mr. Cadman's paper formed a most valuable and interesting record of one of the chief industries of North Staffordshire.

Mr. E. B. WAIN, in moving a vote of thanks to Mr. Cadman for the paper, said that North Staffordshire produced a small proportion of the ironstone raised under the Coal-mines Regulation Act. The great ironstone-mines of the Cleveland district

produced 75 per cent., but of the balance Staffordshire produced almost half, so that Staffordshire still did something in the way of producing ironstone.

Mr. W. STATHAM, in seconding the motion, said that many of the remarks made by Mr. Cadman would sound like a foreign tongue to some of the members, but to him the paper was especially interesting.

The motion was cordially approved.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE SCHOOLROOM, WINCHBURGH, OCTOBER 10TH, 1903.

MR. HENRY AITKEN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. GEORGE L. ALLAN, 95 Bath Street, Glasgow.
Mr. ROBERT BROWN, Manuelrigg Colliery, Polmont Station.
Mr. CHARLES ALFRED JACKSON, Hansville, Leven.
Mr. JAMES RODEN, Eastrigg Colliery, Westfield, Linlithgowshire.

NIDDRIE CASTLE OIL-WORKS AND DUDDINGSTON SHALE-MINES.

The members were received at the Niddrie Castle oil-works by Mr. R. T. Moore, one of the directors of the Oakbank Oil Company, Limited, Mr. Thomson, oil-works manager, and Mr. J. Balfour Sneddon, mining manager, and shewn over the works. They were then conveyed on the electric railway to the Duddingston mines and inspected the surface-fittings and underground workings.

Mr. J. BALFOUR SNEDDON's "Description of the Duddingston Shale-mines and the Niddrie Castle Crude-oil Works" was taken as read, as follows:—

DESCRIPTION OF THE DUDDINGSTON SHALE-MINES AND THE NIDDRIE CASTLE CRUDE-OIL WORKS.

By J. BALFOUR SNEDDON.

Introduction.

The Duddingston shale-mines are situated 2 miles from the crude-oil works at Niddrie Castle; and both works receive the motive power required for all purposes from a central power-station, placed at a distance of 90 feet from the shale-retorts, where all the steam for the engines is used with the least possible loss of heat or power.

The steam required is obtained from three Stirling boilers, fitted with chain-grate stokers (only 2 boilers are in use at any time) placed 6 feet from the power-station, and working at a pressure of 160 pounds per square inch.

On account of the distance of the shale-mines from the power-station, three-phase electric apparatus is installed generating at a pressure of 3,300 volts, 25 periods, with step-down transformers at the power-station for the oil-works, and also at the shale-mines for supplying current at a pressure of 440 volts to the various motors.

Power-station.

The generating units consist of two Westinghouse single-acting, compound engines of the enclosed-crank chamber type, each of which is capable of developing 400 brake-horsepower at 250 revolutions per minute. The engines are fitted with fly-wheel inertia-governors, which act directly on the valves and maintain a perfectly even speed of the engines under a fluctuating load. These engines, being of the single-acting type, the thrust on all the bearings is in a downward direction. To each engine is connected a three-phase generator of 200 kilowatts capacity, 25 periods, and 3,300 volts. The generators are of the revolving field type, and the exciting current is furnished by

two 125 volts direct-current generators, belt-driven from the main shaft (Fig. 1). One engine, meantime, is doing all the work.

At the end of the power-station and situated under the switchboard gallery are the static transformers and rotary transformer. The former receive current at a pressure of 3,300 volts, and reduce it to 440 volts with an efficiency at full load of 96 per cent. The rotary transformer is for converting the three-phase current into continuous current at 500 to 550 volts for use on the electric railway-line (Fig. 2).

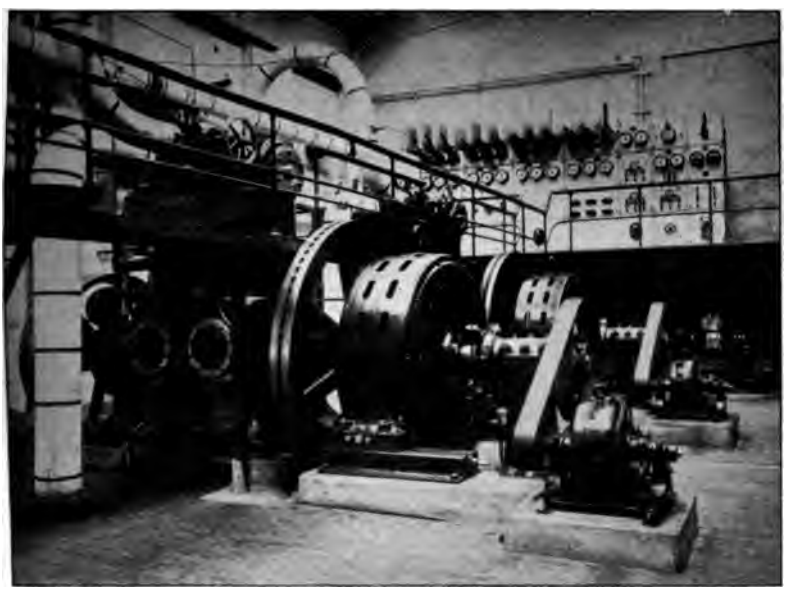

Fig. 1.—Power-station.

There is also a 20 kilowatts motor-generating set for supplying the continuous current required for the lighting of the works. This set comprizes a 30 horsepower induction-motor, directly coupled to a 20 kilowatts generator, and the connections of the generator and the two exciters of the main generators are so arranged that they can all three be run in parallel: in this manner the motor-generator serves as a standby to the exciting sets.

The switchboard consists of an angle-steel framework: to this are bolted panels of white marble, on which are mounted the switches and instruments. There are 2 generator-panels,

1 high-tension feeder-panel for the mine, 1 high-tension feeder-panel for the oil-works, 1 low-tension feeder-panel for the works, 2 panels for the rotary converter, and 2 panels for the exciters and motor-generating sets. A complete system of wattmeters is also fitted, so that the power consumed at the mine, by the electric locomotives and by the works, may be separately computed.

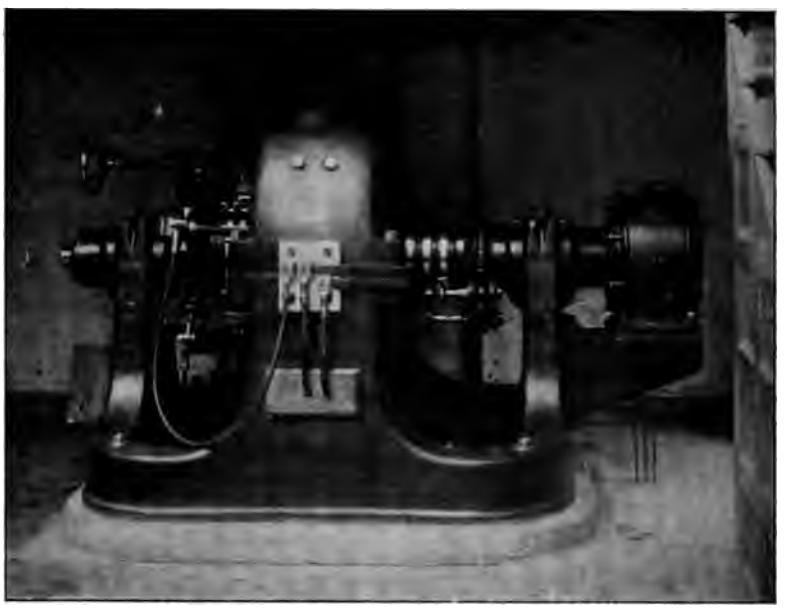

FIG. 2.—WESTINGHOUSE ROTARY TRANSFORMER OF 100 KILOWATTS.

The three-phase induction-motors used throughout this installation are of the Westinghouse type C, 400 volts, the particular feature of these motors being the complete absence of any commutator, slip-rings, or sliding contacts of any description. The revolving part consists of a core built up of iron laminations and solid copper-bars of rectangular section are embedded in the periphery. These bars are connected to copper end-rings by means of bolts. The only wearing parts of these motors are the bearings: the motors may be overloaded excessively for short periods without damage, and they will also start under a heavy load.

The starting device is very simple, and consists of a double-throw switch mounted on a small iron-box, containing an auto-

transformer. When the switch is thrown into the starting position, a reduced voltage is applied to the motor: this produces a smaller starting torque, and relieves the system from constant shocks. When the motor has gained speed, the switch is thrown into the opposite direction, thus applying the full line-voltage.

The following motors are installed in and around the works: 1 motor of 30 horsepower in the exhauster-house, 1 motor of 30 horsepower for the spent-shale haulage, 1 motor of 20 horsepower for the raw-shale haulage, 1 motor of 10 horsepower for the waste-water pump, 1 motor of 10 horsepower pumping at the burn and supplying water to the works, 1 motor of 5 horsepower driving the mechanical stokers, 3 motors of 5 horsepower working the oil-pumps, and a few smaller motors.

The overhead transmission-line from the oil-works to the shale-mine consists of three No. 6 Birmingham wire-gauge hard-drawn copper conductors supported on triple petticoat insulators, carried on poles, 120 feet apart, and at a height of 24 feet from the ground. To these poles are also attached the bracket-arms carrying the overhead-trolley line conveying current to the locomotives. Where the overhead-transmission line crosses roads or railways, and in the neighbourhood of the oil-works, the power is carried by three-core, paper-insulated, lead-covered and armoured cables, laid underground. These cables, where connected with the bare overhead line, are attached to the poles and enter dividing-out boxes bracketted to the poles.

The trolley-line consists of No. 000 Birmingham wire-gauge hard-drawn trolley-wire supported on side-brackets attached to the transmission-line poles and at the sidings carried on span wire. The overhead construction is generally similar to that employed on overhead electric tramway-systems. The rails are efficiently bonded with No. 00 bonds over each fish-plate and cross-bonds in intervals of 100 feet, so as to form a path of low resistance for the returning current.

The locomotives are of the Baldwin-Westinghouse type, each being fitted with two motors and magnetic blow-out controller. They are each capable of hauling a load of 40 tons at an average speed of 10 miles an hour.

Duddingston Shale-mines.

In the sub-station at the mines, there are step-down transformers for transforming the current from 3,300 volts to 440 volts. Three transformers of 100 kilowatts capacity each are ordinarily used, with a fourth as a standby. The transformers and switchboard for handling the high- and low-tension currents are situated at the end of the main-haulage house, the switchboard being placed on a gallery above the transformers. The switchboard comprizes one high-tension panel for closing the circuit from the power-station, and two low-tension panels for closing the circuits to the motors at the mines.

Fig. 3.—Sub-station: Endless-rope Haulage-gear driven by Motor of 150 Horsepower.

The most interesting feature of the installation at the mines is the main haulage, of the endless-rope type, driven by a Westinghouse induction-motor, type F, which is started and stopped by a controller of the tramway type, although on a somewhat larger scale. This motor differs from those of type C, previously described, in that it has a revolving element with a special winding connected to slip-rings, and this winding enables the motor to be run at a reduced speed for short periods when necessary (Fig. 3).

The other motor-drives at the mines consist of 1 motor of 30 horsepower operating the shale-breaker, 1 motor of 20 horsepower driving the ventilating-fan, and 1 motor of 30 horsepower working an underground pump.

The Nos. 1 and 2 mines are driven in the Dunnet seam, following the shale from the outcrop-line. The gradient averages about 1 in 5 for the present depth of over 2,400 feet, the first 1,200 feet showing about 1 in 4. The mines are spaced 60 feet apart, No. 1 is 12 feet wide and 8 feet high, and No. 2 is 10 feet wide and 7 feet high. The seam is 13 feet thick, and the develop-

Fig. 4.– Mine-head House.

ment is being done in the centre of the seam, 3 feet of shale being left on above and below the present working. During sinking operations the average speed obtained was 33 feet per week.

Haulage.—The system of haulage in No. 1 mine is one form of the endless-rope system, the rope being carried over the hutches; the attachment is made by means of short bridle-chains, about 12 feet long, hitched on to the rope. The benches are spaced at intervals of 240 feet, and it is intended to deliver

120 tons at each bench. The rope is carried at the benches by means of mushroom-shaped wheels, which allow the bridle-chains to slip through and thus obviate the necessity of detaching the chains at each bench. Access is obtained, from side to side, by means of a bridge placed over the haulage-road. The rope is driven, through gearing, by the motor of 150 horsepower, already described, at a speed of 142 feet per minute. The ratio of speed betwixt the motor and the drum is as 1 to 120. The drum is 10 feet in diameter, and the rope is 1¼ inches in diameter. With hutches spaced 40 feet apart on the rope, an output of 90 tons an hour can be obtained. The present output is about 500 tons a day, and is being gradually increased.

Fig. 5.—Electric Locomotive and Bogies at Mine-head House.

Ventilation. The Capell fan, 8 feet in diameter and 3½ feet wide, driven by a motor of 20 horsepower running meantime at 230 revolutions per minute, is producing 60,000 cubic feet per minute at a water-gauge of 0·5 inch. The fan is situated between the mines, both being inlets, the air returning along the inside headings, and is carried over to the fan-drift, by means of air-crossings.

Pumping-plant.—The water, meantime, is a somewhat negligible quantity, and is dealt with by means of a treble-ram vertical pump of Worthington type, 7 inches in diameter by 10 inches stroke. This pump is equal to 100 gallons per minute, against a static head of 660 feet. The motor is of 30 horsepower and the ratio of the gearing betwixt the motor and the pump is as 1 to 28. The present growth is about 20 gallons per minute, 5 per cent. of the quantity ultimately to be pumped.

FIG. 6.—ENDLESS-CHAIN HAULAGE-INCLINE LEADING TO THE TOP OF THE RETORTS.

CRUDE-OIL WORKS.

Retorts.—The broken shale from the mines is carried to the retorts by two electric locomotives in bogies, with hopper-bottoms and sliding-doors, holding about 24 cwts. each, and left in lyes about 360 feet from the retorts. Thence the bogies are raised by an endless-chain haulage-incline to the top of the retorts and emptied into the hoppers, which form the top of the retorts (Fig. 6). Each retort has a hopper capable of holding 7 tons of shale, thus containing a surplus supply over that required during the night, and obviating the necessity of charging during the night. There are two benches of 64 retorts

each, putting through 500 tons daily. The total height of the retorts is 57 feet from the ground-level (Fig. 7).

The retorts are heated externally by the waste-gases from the destructive distillation of the shale, after condensation of the vapours by cooling and scrubbing with water and oil. The retorts are vertical and circular in section, and narrower at the top than at the bottom, so as to allow of the easy descent of the shale. The top portion of the retorts is made of cast-iron and the lower portion of brickwork. The oil is distilled and driven off from the shale

FIG. 7.—TWO BENCHES OF RETORTS FOR DISTILLING OIL-SHALE, CRUDE-OIL AND AMMONIA-WATER CONDENSERS, AND POWER-STATION.

in the upper or iron portion of the retorts, and as the shale descends to the brick or lower portion, the heat becomes greater until a sufficient temperature is attained to decompose steam by the carbon in the spent shale, liberating nascent hydrogen to form ammonia with the nitrogen left in the oil-denuded shale.

Steam is supplied to each retort by a pipe entering the bottom hopper at a low pressure from the engines, etc., or from the steam-boilers. There is a cast-iron table in the bottom hopper on which the shale rests, a few inches under the retort. On this

table, a quadrant revolves slowly and at a regulated speed, transferring the spent shale from the retort into the bottom hopper. The quadrant is operated by a ratchet-and-lever driven by a bar common to all the retorts in one bench. The spent shale is dropped from the bottom hopper at intervals, by a bell and lever, into a hutch, which carries the exhausted shale up an endless-chain incline of 1 in 6 to the top of the spent-shale heap and is there emptied.

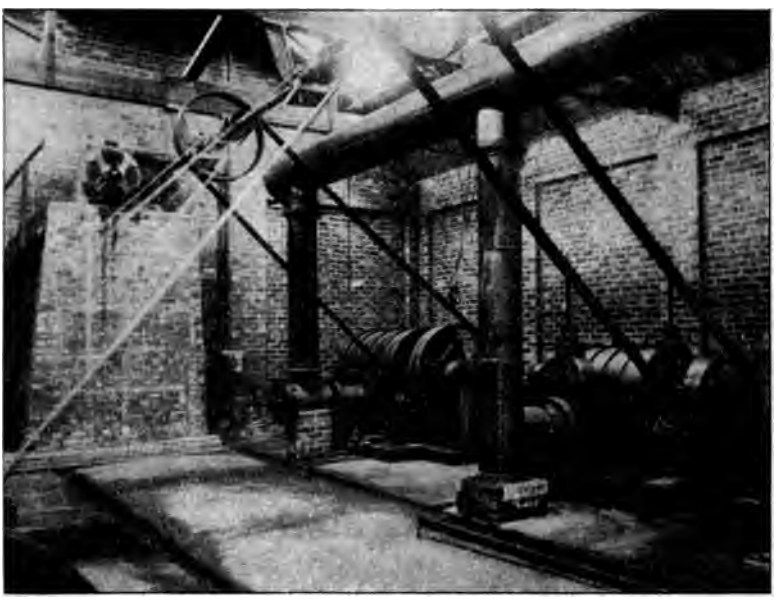

FIG. 8.—GAS-EXHAUSTERS AND PUMPS DRIVEN BY WESTINGHOUSE TYPE C MOTOR OF 30 HORSEPOWER.

Condensers and Scrubbers.—The oil and water vapours leave each retort at the top by an outlet pipe, 8 inches in diameter, entering a common main, 30 inches in diameter. This main passes the gases into a water-heater and then into larger upright air-cooled condensers, formed of light cast-iron spigot and faucet-pipes, fitted with cast-iron chests and resting on them. The uncondensable gases then pass into exhausters, which continually maintain a slight suction on the retorts (Fig. 8). Next, under slight pressure, the gases pass from the exhausters into a vertical water-scrubber, where the last traces of ammonia are removed: they then pass into a similar scrubber, where

mineral oil is used to wash the gases, as it has the property of abstracting the light oils and naphtha from the gases.

The oil from the scrubbers is steamed in a vessel containing a series of plates and cups with corrugated edges, the steam denuding the mineral oil of the absorbed naphtha, which is condensed in an iron worm, surrounded by water. The crude naphtha is separated from the water that comes over with it, and is sent to the refinery to be finished. The denuded oil is cooled by a water-cooler, formed of pipes lying in cold water, and after cooling, the oil is again pumped through the scrubber to repeat the process, and so on continuously.

The crude oil and the water condensed in the air-condensers separate automatically by their different specific gravities. The oil is pumped into charging-tanks, whence it is filled into railway-wagons and carried to the refinery.

Ammonia-house, etc.—The water from the same condensers contains the ammonia, and is pumped to the ammonia-house, for manufacture into ammonium sulphate. The water is passed into a vertical tower of malleable iron, filled with a number of plates or shelves, in which are placed large cups with corrugated edges. As the water passes from plate to plate, downward, it meets a current of steam passing upward from below; this steam separates the ammonia-gas from the water, and carries it off through an outlet-pipe at the top of the tower or still, into the sulphuric-acid saturator. The ammonia-gas and the steam enter the acid solution through a perforated coil and are greedily absorbed by the acid, ammonium sulphate being thus formed. The ammonium sulphate falls in crystals to the bottom of the vessel, is fished out by a steam-injector, and thrown into a perforated box on an overhead railway. When this box is full and drained, it is run over to and emptied into large stalls or bins, fitted with false bottoms, where it is further drained until dry and ready for the market. These stalls each hold 70 tons.

The spent ammonia-water from the bottom of the still is used to heat the incoming ammonia-water. Next, it passes into a drain, with other waste water, to a catch-pond (for all water from the works), whence it is pumped into the sea by a treble-ram vertical pump and motor, at the rate of 7,000 gallons per hour.

Water-supply.—The fresh water required for the use of the works is pumped from a burn, ¾ mile from the power-station, by a pump, similar to that already described for pumping the waste water. The water is first used in the light-oil condenser and oil-coolers, then in the retort water-heaters, whence it passes to a water-softening plant before entering the high-pressure steam-tube boilers.

The system is proving very economical, especially in regard to fuel-consumption and otherwise is giving general satisfaction.

The electrical installation has been supplied by the British Westinghouse Electric and Manufacturing Company, Limited.

The following paper by Mr. Alexander Faulds on "Mine Dams" was taken as read:—

MINE DAMS.

By ALEXANDER FAULDS.

Introduction.—During the existence of this Institute, which has just celebrated its Semi-Jubilee, little attention seems to have been given by the members to the subject of dams in mines. Dams are perhaps of some importance to many of the members, and probably more so to those who have been compelled under certain circumstances to construct them, by way of flooding a mine with water in case of fire, or keeping back water in old, abandoned, and adjoining workings.

The chief object, in compiling these notes has been to initiate a discussion on this important subject, and to ascertain, and record, the opinions of those members who have had occasion to construct such dams, and who probably may be the best judges as to what should constitute the best dam.

Character.—Dams are specially characteristic, and therefore demand special study by the mining engineer. Their erection does not, as a rule, offer great difficulties; but a full understanding of their existing conditions is required to ensure their efficiency.

Reference may be made to the *Mine Foreman's Handbook, 1893*,* by Mr. Robert Mauchline, late inspector of mines, Pennsylvania, a native of Larkhall, Scotland; *A Practical Treatise on Coal-mining, 1876*,† by Mr. George G. André; and to the *Transactions of The Institution of Mining Engineers*,‡ in all of which some dams are fully described.

Prof. W. Steadman Aldis, in a valuable paper on "Internal Stress in Cylindrical Dams,"‖ gives the following formulæ for determining the minimum thickness of cylindrical and spherical dams, in which k is the minimum thickness in inches; r, the external radius in inches; T, the ultimate crushing strength

* Page 223. † Page 506.

‡ Vol. i., page 409; vol. iii., page 132; vol. vii., page 729; and vol. xix., pages 549 and 550.

‖ *Trans. N.E. Inst.*, 1883, vol. xxxii., page 201.

of the material used in constructing the dam, in pounds per square inch; and p, the head of water in pounds per square inch:

Cylindrical dam:—

$$k = r\left(1 - \sqrt{1 - \frac{20p}{T}}\right) \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Spherical dam:—

$$k = r\left(1 - \sqrt[3]{1 - \frac{15p}{T}}\right). \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In these formulæ, the values of $\frac{20p}{T}$ and $\frac{15p}{T}$ must be less than unity. If they are greater than unity the material proposed to be used is not strong enough, and another must be selected. The factor of safety is taken as 10, and is allowed for in the formulae.

Requirements.—The two principal requirements are:—(1) The dam must be perfectly water-tight, and (2) must be capable of resisting the water-pressure. To be perfectly water-tight, the dam must be constructed of impervious materials, and the pressure must tend to close the well-caulked joints of the structure without causing it to be deformed.

Site.—The site demands special attention, and must be chosen at a point in the roadway, drift or shaft, as the case may be, in the most solid place available, and, if possible, where the rock is strong and sound.

Dams are sometimes built by arching from side to side (Fig. 1, Plate III.); but if the place, where the dam is to be built, is very wide in proportion to its height, perhaps the arching is preferably built from the bottom to the top (Fig. 2, Plate III.), and for shafts, double dams, back to back (Fig. 3, Plate III.), may be built with concrete filling between them.

The roof, floor or pavement, and the sides, require to be carefully cut to form the faces of a pyramid, or cone, having its apex or point beyond the site of the dam, determined by the pressure. These faces are usually made about 6 feet long. The apex or point will be the centre of a sphere or circle, towards which the four faces or the two side-faces converge. If the rock be suitable, these faces should be made true and smooth; and if rough they must be cemented.

Material.—Sometimes ordinary composition brick, well and hard burned, is used, set with cement-mortar; concrete; and sandstone and mortar or masonry. The material most frequently used is timber: sound well-seasoned oak being preferred (Fig. 4, Plate III.).

Construction.—When timber is used, the pieces, from 4 to 5 feet long, are squared and tapered according to the radius of the arch to be formed; and laid side by side in rows, the joints breaking bond, forming an arch of wooden billets or voussoirs, the lengths generally being proportioned to the pressure, a common length being about 5 feet. It is absolutely necessary that the voussoirs be accurately cut, in order to bear uniformly upon each other throughout their whole length. The pieces should be put together on the surface, numbered for reconstruction underground, in a thoroughly dry condition, in the same position. The joints must be wedged and caulked on the side or face of the dam next to the water.

A way of egress, for the water and men during construction, is provided by a conical cast-iron pipe, large enough to allow a man to crawl through, built in near to the bottom of the dam. A small bay, a little above the dam, is generally provided, and the water is led from it by flexible tubing through the egress pipe.

When the dam is completed, the egress is closed by a conical wooden plug made to fit the pipe, and covered near its larger end with vulcanized indiarubber or similar material to ensure a water-tight joint; and the subsequent pressure of the water will force the plug in still more firmly.

It is sometimes desirable to arrange for the air to escape through an auger-hole bored through one of the voussoirs, a small iron tube being carried from the inside to a small cavity in the roof. When water begins to issue from the auger-hole, and all the air has escaped, the hole is plugged with wood.

To prevent the disastrous consequences entailed through the yielding of dams, they should possess excessive strength (at least double the calculated thickness). When they are required to resist moderate pressures, a simpler structure than the timber-dam described can be adopted.

Masonry is sometimes used, consisting of two or more concentric arches placed several feet apart, the intervening space

between them being filled with well rammed clay. The least yielding of the masonry-abutments causes breakage, and, of course, leakage, and renders them generally unsuitable.

The following is a description of a timber-dam erected in the Extension mine, near Nanaimo, Vancouver Island, owned by the Wellington Colliery Company, Limited (Fig. 5, Plate III.).

The construction of this dam was necessitated by a fire which occurred in No. 2 slope-mine, on September 30th, 1901, about 11 a.m., whereby 16 lives were lost. The fire is supposed to have started from the ignition of a curtain or screen. Careful observations of the temperature were regularly taken, and recorded for three months: after which it was decided to flood the mine or fire, by constructing a wooden dam in the tunnel leading to the workings, and outside of a sealed stopping.

The site selected was in the sand-rock, forming the pavement or floor of the coal-seam, in a tunnel, 15 feet wide by 8 feet high. The roof, floor or pavement, and the two sides were carefully prepared. The material for the voussoirs was Douglas pine, got on the island. Brattice-curtain or screen-cloth was also used, and tar. The wedges used were also made of Douglas pine.

The dam was of circular form, and the voussoirs were 8 feet long and tapered from 8 inches by 12 inches to 8 inches by 8 inches at the smaller end. The beds of the courses, and also between the voussoirs, were laid with well-tarred brattice-cloth; and it was thoroughly wedged tight, after the voussoirs had been placed in position.

A temporary clay-dam was erected on the inside of the permanent dam, and the water was conducted therefrom, through an exit-pipe, which was made of steel and of sufficient diameter to admit of a man crawling through it. This pipe was closed with a well-stayed blind flange; and on this a gauge was fixed, for indicating the pressure.

The pressure or head was 130·2 pounds per square inch, or a head of 300 feet. The dam was of circular form, the radius of the extrados being 20 feet, and of the intrados 12 feet, and the height was 9 feet. The thickness of the dam was 8 feet, and the formula (2) required a thickness of at least 7·92 feet.

Figs. 6 and 7 (Plate III.) illustrates a brick-dam that was constructed in Kehley Run colliery, at Shenandoah, Pennsylvania,

to isolate a portion of the seam, in order that it might be flooded to extinguish a mine-fire. This is one of the largest mine-dams that has ever been constructed. It is composed of three brick arches, each having a thickness of 5 feet, and placed one against the other so that they act as one solid structure. The gallery is about 20 feet wide, and the distance to the next upper level is about 119 feet. It was intended that this should be the maximum head of water that the dams would ever have to resist, although they were made sufficiently strong to resist a head of water reaching to the surface. The separate walls were constructed one at a time, and the cement allowed to set before the next wall was built. The back wall was carried to a greater depth and height than the others, so as to ensure that all slips or partings had been closed. The total pressure upon the dam when the water was in the mine was about 486 pounds per square inch.

When fires are flooded, in face of danger, it is necessary to erect temporary stoppings so as to exclude the air and smother the fire; and thus to prevent it from spreading upwards or where the water could not reach it. If the enclosure be not complete, the fire will continue to spread; if the enclosure be tight, the gases from the fire are forced through every crevice and may endanger the workmen employed at the dam. If fresh air be admitted into the enclosure to carry off the gas, it may cause an explosion by mixing the carbonic-oxide gas with the proper percentage of air; consequently the operation is attended with extreme danger. In all cases the ventilating current should be arranged so that the workmen are in the intake or fresh air, and that any gas from the fire will be carried away from the men. Care should also be taken that the return-air cannot double back and mix with the intake-air.

To illustrate Mr A. Faulds' Paper on "Mine Dams."

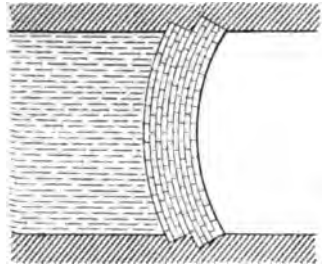

FIG. 1.—PLAN.

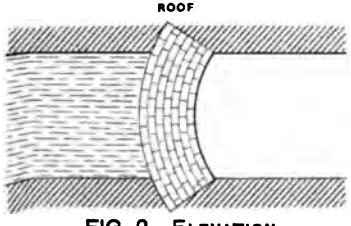

FIG. 2.—ELEVATION.

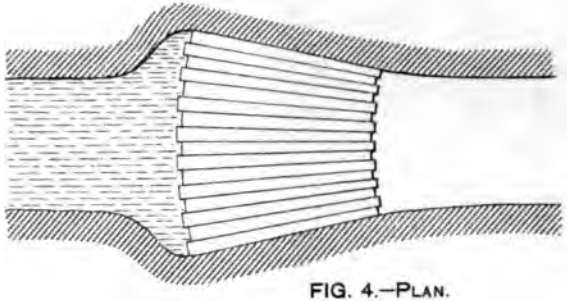

FIG. 4.—PLAN.

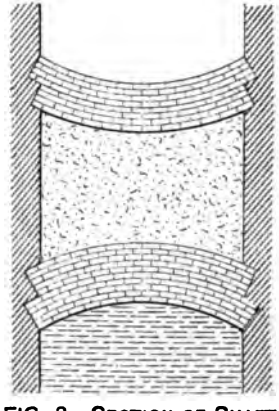

FIG. 3.—SECTION OF SHAFT.

Scale, 10 Feet to 1 Inch.

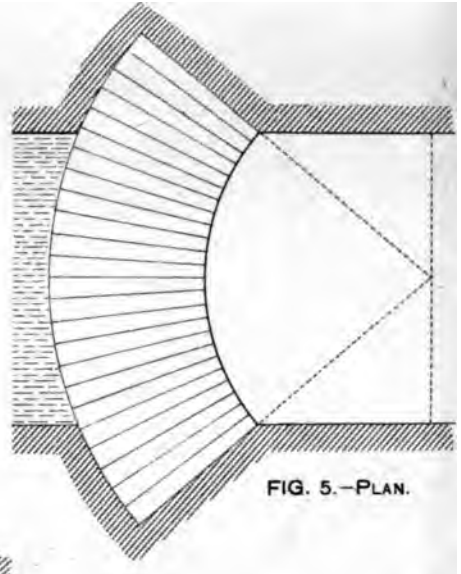

FIG. 5.—PLAN.

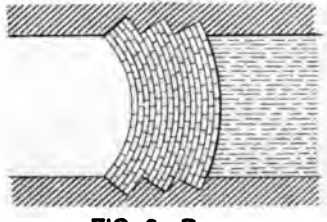

FIG. 6.—PLAN.

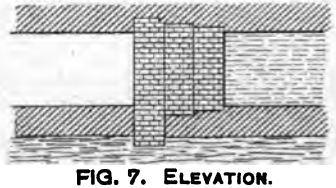

FIG. 7. ELEVATION.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, OCTOBER 10TH, 1903.

MR. W. O. WOOD, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on September 26th and that day: and also the proceedings of the Council of The Institution of Mining Engineers on September 2nd.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

MR. SYDNEY HORSLEY, H.M. Inspector of Mines, Charters Towers, Queensland, Australia.

MR. WALTER MAURICE REDFEARN, Mechanical Engineer, Horden Colliery, Castle Eden, R.S.O., County Durham.

MR. JAMES BERTRAM SAMPLE, Mining Engineer, Harraton Colliery, Chester-le-Street, County Durham.

MR. JOHN JAMES WHITEHEAD, Mining Engineer, P.O. Box 6407, Johannesburg, Transvaal.

ASSOCIATE MEMBERS—

MR. CLARENCE ADRIAN BISHOP, Mooi River, Natal, South Africa.

MR. JAMES THOBURN CACKETT, 24, Grainger Street West, Newcastle-upon-Tyne.

MR. ALEXANDER MILLER, Wollongong, New South Wales, Australia.

MR. DAVIDGE PAGE, Clun House, Surrey Street, Strand, London, W.C.

STUDENT—

MR. JOHN ALLAN EADIE, Jun., Apprentice Mining Engineer, Eller Bank, Harrington, Cumberland.

SUBSCRIBER

MESSRS. BRUNNER, MOND & COMPANY, Limited, Northwich, Cheshire.

REPORT OF THE DELEGATE TO THE CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, SOUTHPORT, 1903.

The report of the proceedings of the Corresponding Societies' Committee of the British Association for the Advancement of Science, and also that of Mr. John Gerrard, the delegate representing the Institute was read as follows:--

WORSLEY, MANCHESTER,
October 7th, 1903.

TO THE PRESIDENT AND COUNCIL OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENTLEMEN,

I attended the two meetings of the Conference of Delegates of Local Societies held at Southport, on September 10th and 15th.

There was a discussion upon convincing the "man or boy in the street" as to the practical advantages of a knowledge of science. A resolution was passed, that it is desirable that scientific workers, and persons interested in science, be so organized that they may exert permanent influence on public opinion, in order more effectually . . . to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress . . .

The following papers are of some interest to the members:—

"Presidential Address." By Sir Norman Lockyer.
"Presidential Address (Section C – Geology)." By Prof. W. W. Watts.
"Terrestial Magnetism in its Relation to Geography." By Captain Ettrick W. Creak.
"The Equipment of the Manchester Municipal Technical Institute." By Mr. J. H. Reynolds.
"Liquid Fuel." By Mr. A. M. Bell.
"The Ventilation of Tube-railways." By Mr. J. W. Thomas.
"Presidential Address (Section F—Economic Science)." By Mr. Edward W. Brabrook.
"The Preservation, Seasoning, and Strengthening of Timber." By Mr. W. Powell.

I am, Gentlemen,
Yours faithfully,
JOHN GERRARD.

DISCUSSION OF THE "REPORT OF THE COMMITTEE UPON MECHANICAL COAL-CUTTING."

Mr. T. E. Forster (Newcastle-upon-Tyne) said that the object which the Committee had in view when the *Report* was prepared was that it should give as much general information on coal-cutting, as could be collected up to the date of its publication; not necessarily information of a scientific character, but such as would be of use more especially to those who had not had any long experience with coal-cutting machines. Some 30 collieries were visited in all parts of Great Britain, where coal-cutting machines were being worked, principally in Scotland, the Midlands, Yorkshire and West Lancashire. He was of opinion that mechanical coal-cutting was likely to increase in the near future. The quantity of coal got by coal-cutters in this country had risen from a little over 3,044,321 tons in 1901 to 4,161,202 tons in 1902, or 36 per cent. in one year.* It was interesting to note that the largest output was from the Yorkshire district, with 1,349,997 tons from 129 machines; the Midland district came next with 812,132 tons from 93 machines; the two districts of Scotland produced 756,813 tons with 85 machines; Newcastle-upon-Tyne district 249,291 tons with 23 machines; and Durham 223,109 tons with 30 machines, or a total for the counties of Durham and Northumberland of 472,400 tons with 53 machines. One could not help noticing, in comparison with its size, that this district was considerably behind other districts in the matter of mechanical coal-cutting. Whether it was that there was not the necessity for it that existed in the south, or that the seams there were more suitable, he was not prepared to say; probably, the labour-conditions were not so well suited to mechanical coal-cutting as in the Midlands or in Scotland. The Committee called attention to the fact that the arrangement of the system of working was more than half the battle. If a suitable coal-cutter for the work was selected and put down with proper appliances, there could be no doubt that it would work satisfactorily, but unless they arranged the labour and fixed the hours and conditions properly, it was of very little use

* *Mines and Quarries: General Report and Statistics for 1902*, 1903, pages 114 and 115.

to adopt mechanical cutting. Although backward as regards the number of machines in use, the produce per machine showed that this district stood in a favourable position. Staffordshire showed the highest produce per machine, 11,600 tons; Northumberland came second with 10,800 tons, being a little better than Yorkshire at 10,400 tons. Judging from one's observations of coal-cutting in Northumberland, it was not the thickness of the seams that tended to the production of the greater quantity, but more attention had probably been given to the nature of the work, and to keeping the machine always at work. In some cases in the south, the machines were not kept continually at work, and as they were only occupied about half the time, the capital charges and interest came out much higher.

Mr. W. R. Dakers (Tudhoe Collieries) referred to a statement in the *Report* that "the costs of motive power, repairs, and interest on capital, which appear, under average conditions, to amount to about 4d. or 6d. per ton raised."* Elsewhere it was mentioned that "the highest cost under these heads, which had been ascertained at the collieries visited, is 1s. 2½d. a ton, and this appears to be largely due to the use of unsuitable plant; and in many instances it is put at 4d. per ton. It may be asserted with confidence that, in most cases, it will be covered by 7d. a ton with some margin on the right side."† Two examples of machines were referred to, in the Appendix, in the county of Durham: At No. 20 colliery,‡ there was an output of 6·25 tons per man per shift, with a cost for other labour in face of 1s. 0·17d. per ton: while at No. 31 colliery,§ with an output of 2·87 tons, the same labour-cost was 9·75d. It was difficult to reconcile these figures.

Mr. T. E. Forster, with reference to the cost of repairs, said that it was difficult to find collieries where everything was accounted for separately, and in the case of the high figure of 1s. 2½d. per ton, it was mentioned that this appeared to be largely due to the use of unsuitable plant. From 4d. to 6d. per ton was the figure quoted by users of machines, although they could not always substantiate the figures. No doubt, after making all the enquiries, the Committee had come to the conclusion that 7d. per ton might be taken as a safe figure;

* Page 4. † Page 31.
‡ Page 39. § Page 41.

possibly 6d. or even 5d. might cover it, but it would depend on the seam. It was difficult to get at the exact figure per ton; and it would probably be fairer to quote a price per square yard. Referring to the labour-cost and the output per man per shift, he would not like to say how the difference arose; the figures were all certified by the colliery-managers who supplied them, and no doubt an explanation would be forthcoming. There was a great deal of difference in the cost of filling the coal: at some collieries, half the filling was done by putters, in others it was filled by hewers at datal wages, and this was the principal difficulty met with in a district in which they had not defined who was a filler, and what he was to be paid.

Mr. R. Hood Haggie (Derby) wrote that the *Report* went so fully into all the details that it was difficult to add anything of interest. He noticed that, with the exception of bar-cutters, nearly all the tools were chisel-shaped, and the *Report* read as though disc-machines could only use chisel-tools. He had recently tried some pick-pointed tools in a disc—using about half pick and half chisel—and he found a great advantage in doing so, as it reduced the current on a 500 volts circuit by 5 ampères. In this case, the top of the band, in which the holing was made, was friable and the bottom tough. He had found that the mixing of pick and chisel-tools on the disc in some places was advantageous, as it increased the time-interval, before it became necessary to change the set. In electrically-driven coal-cutters one of the chief causes of breakdown of armature and gearing lay in the switch, and that might be due either to the design or to the manipulation. Manufacturers gave too little thought to it, and machine-men did not seem able to grasp the necessity of starting the motor slowly. Unfortunately the space afforded to the switch was very limited, and did not allow for the attachment of all the safety-devices which one would like to utilize. There was seldom room to put in a switch, with ample resistances and with the handle arranged so that however quickly it could be pushed over the contact-arm took its proper time, and arranged with a quick break-action, a no-voltage release and an overload cut-out. Yet all these devices were deemed necessities for a motor on the surface, where it was working under the best of conditions. Undoubtedly the motor was placed in the most trying position on a coal-cutter, and a reli-

able switch was so essential to its satisfactory working that he thought some space should have been reserved in the *Report* for that subject.

Mr. Fred W. Hurd (Bothwell) wrote that he had read with great interest the Report of the Committee: from the introduction right through to the appendix it was a valuable and thoroughly practical piece of work, and anyone introducing coal-cutting machines into a mine could not do better than take this *Report* as a handbook on coal-cutting and work up to the book. It was gratifying, from a machine-maker's point of view, to see that stress was laid upon the importance of having the machine-face straight, and having stables cut at each end of the face. These points did not generally receive the consideration that they deserved. The description given of the Hurd machine, and its special features, was a very fair one; but he desired to add the following particulars:—(1) With a bar, 3½ feet long, the machine did make its own pavement. (2) The cuttings were cleaned out as well as, if not better than, with any other type of machine. (3) It was an open question whether or not it was better to cut across a stratified material vertically instead of horizontally: there was undoubtedly less friction when cutting vertically as shewn by power-diagrams. (4) The small machine was working in a seam, which was in some places only 17 inches high. (5) The compressed-air machine referred to was working, and was probably the simplest and strongest machine ever put into a pit. And (6) it was only in rare instances that the cutter-bar and direction of rotation of the motor required alteration when back-cutting.

The three-phase cutters referred to at Ackton Hall, were Hurd machines, and several others had lately been set to work at this and other collieries with excellent results. At the machine, three-phase current was a distinct advantage, as no brushes with their multiplicity of parts to get out of order were required. From the generator to the machine, however, the simplicity disappeared, and the heavy starting current was a disadvantage, as it prevented the use of a fuse-wire of a section small enough to be considered a safeguard for a motor, as in a direct-current plant.

Referring to the tables, he was naturally delighted to find that the Hurd machine showed the greatest saving per ton over hand-worked coal. The seam was recognizable, and he must in

fairness say that credit for the low cost of holing was due in great part to the clever way in which the machine-face was set out. The expense of flitting was reduced to a minimum, in fact he had known the machine cut between 20 and 30 yards at one end of the face, and then be flitted and cut 40 yards at the other end, all in one shift of 9 hours. The cost of flitting was overstated in the *Report*, and the subject should receive special attention in each case. The tables would have been more complete, if, in the case of electrical machines, the ampères taken as well as the voltage had been given.

Mr. H. F. Bulman (Barcus Close), with reference to the figures of costs, wrote that the object desired was to show what saving, if any, is obtained by the use of machines. As stated in the *Report*,* these figures were supplied by the colliery-managers in the form and under the heads stated in the schedule; and, therefore, should be reliable, as showing the relative cost of machine-cutting *versus* hand-work in each case. But it is not always easy to differentiate exactly the "labour in face," and in some cases, probably, the figures cover more or less shift-work and stone-work than in others.

As regards the discrepancy referred to in connection with No. 31 colliery, it is explained in the foot-note that the cost of stone-work is not included in the figure given, and that when this is added, there is practically no saving over hand-work.†

As to the cost of repairs and motive power, and interest on capital, the larger the output from the machines, the smaller will be the cost per ton of these upstanding charges. When continuous-current electric coal-cutters are first put into the hands of inexperienced men, the cost of repairs, owing to burnt-out armatures and other mishaps, is sometimes very high. There is a wide variation at different collieries, but such figures, as could be obtained, justify the statement in the *Report*, that in most cases it is covered by 7d. a ton.

If colliery-managers, who use machines, would give the members the benefit of their experience, by supplying particulars similar to those contained in the schedule, it would form a valuable supplement to the *Report*.

The President (Mr. W. O. Wood) said that, as there was a considerable variety and thickness of seams, so there was a great

* Page 3. † *Report*, page 41.

variety of machines employed, which made it difficult if not almost impossible to obtain fair comparisons. Mechanical coal-cutting was only in its infancy, and in some cases the power utilized was also applied to other purposes simultaneously: in the case of compressed air, sometimes to hauling and pumping-engines, and it was difficult to estimate with any degree of accuracy what was the cost of the power supplied to the coal-cutting machine. There might be some cases where the power was used only for coal-cutting, but even there the figures would not be quite so reliable as one might like to have them: for, as it was pointed out in the *Report*, mechanical coal-cutting in this district had only attained the experimental stage. He thought that the Committee had performed a most useful work, and had compiled a large volume of extremely valuable information, and, so far as the present state of the mechanical coal-cutter was concerned, the *Report* was as good and clear an account as the members could have. When mechanical coal-cutting came more generally into operation (as no doubt it would) and they adopted the methods of working alluded to by Mr. Forster, and got their labour into order (and that was the important factor), he did not see why the counties of Durham and Northumberland should not show as good an account of themselves in coal-cutting as they had done in everything else. The members were exceedingly obliged to the Committee for their interesting *Report*, and he had pleasure in moving a very hearty vote of thanks to them for their services.

Mr. W. R. Dakers seconded the resolution, which was cordially approved.

Mr. David Burns' paper on "The Anthracitation of Coal" was read and discussed.

Mr. Edward S. Wight's paper on "Bore-holes for Pumping Purposes" was read as follows:—

BORE-HOLES FOR PUMPING PURPOSES.

By EDWARD S. WIGHT.

The writer is induced to lay before the members a description of a method by which a bore-hole can be used for pumping purposes; not as an engineering feat, but rather to shew that the water generated in the distant workings of a mine may in many cases be delivered direct to the surface, thus saving long ranges of pipes underground and probably several handlings of the water.

At one of the mines under the writer's charge, the pumping was done in three stages: No. 1 pump being adjacent to the shaft-bottom, No. 2 pump being 1,200 feet inbye and No. 3 pump a further distance of 330 feet inbye. No. 2 is 60 feet lower than No. 1 pump, and No. 3 is 50 feet lower than No. 2 pump. The water was pumped from one pump to the other, and No. 1 pump forced the water direct to the surface. As No. 1 pump was too small to deal with the water made at its own level, and also that delivered to it by No. 2 pump, within 8 hours, this involved a second shift of pumping.

To avoid using a larger pump instead of No. 1 pump, and also a larger column of pipes to the surface, it was resolved to put down a bore-hole on the west side of the Waikato river, so as to enable No. 2 pump to force the water direct to the surface. The necessary survey being made, a contract was let to put down a bore-hole and line it with a pipe, 5 inches in diameter: the price being 4s. 6d. per foot for labour only, for a depth of 242 feet.

It was known that down to a depth of about 100 feet the bore-hole would be made in quicksand, consequently a pipe 6 inches in diameter was driven through this, and through it a pipe 5 inches in diameter would be telescoped. To enable this to be done, it was necessary to slightly turn down the couplings of the pipes, 5 inches in diameter, in order that they might pass through the pipes, 6 inches in diameter. At the bottom of

the quicksand, 115 feet deep, a log of wood, 18 inches thick, was struck on one side; and, to prevent the sand from running, it was necessary to drive the pipes, 6 inches in diameter, through the log after it was chipped away sufficiently. [Samples of these chips were exhibited to the members.] It was afterwards found that the driving of the pipe past the log had deflected the hole slightly, and to such a degree that after the hole was pierced into the workings the pipes, 5 inches in diameter, would not travel past the deflection, on account of the couplings being so neat a fit. An endeavour to procure pipes 4½ inches in diameter in the colony proved fruitless; the hole was therefore lined with pipes, 4 inches in diameter. These slipped down with great freedom, so that the deflection of the bore-hole could not have been very great.

The water from No. 2 pump is now forced direct to the surface through the bore-hole, and it is intended shortly to work No. 3 pump, at which station there is only a small quantity of water, as a hydraulic, taking the power from the column of No. 2 pump. By this arrangement, the water is now easily pumped out in 8 hours, and the services of two men dispensed with, effecting a saving of 17s. per day. Probably the same result could have been obtained by increasing the size of No. 1 pump, but considering the circuitous route of the pipes from that pump to the shaft-bottom, and other conditions prevailing, it was considered best to adopt the bore-hole, sufficient pipes being released in the distance of 1,200 feet to No. 2 pump to almost pay for the work.

A brief description of the Gilberd boring-machine, used for putting down the bore-hole, may prove of interest. It is a percussive rotary machine, using an ordinary chisel on pipe-rods, through which water is pumped to bring up the dèbris. The stroke is obtained by a hempen rope wound around a friction-drum, the attendant holding the rope-end until the necessary lift is attained, then suddenly releasing it and allowing the rope to surge on the drum, and thus any length of stroke can be obtained. The turning motion of the drill is produced by clamping a toothed wheel upon the rods, the wheel gearing into a fluted column, about 5 feet high; and this column is made to revolve at a speed of one revolution of the rods to about every 5 strokes of the chisel. When starting, the toothed wheel is set

near the top of the fluted column, so that 4 feet or more can be bored before it need be raised again. It is claimed that the machine is capable of boring through almost any rock, and it has done rapid work when boring for water, where a record of the section of the strata is only a secondary consideration. In Auckland, the Gilberd machine has bored a hole, 3 inches in diameter, through the sandstones of the Waitemata, 1,135 feet deep, in 8 weeks; in the same locality, a hole, 6 inches in

FIG. 1.—THE GILBERD BORING-MACHINE.

diameter, was bored to a depth of 400 feet in 15 days; at Otahuhu, 9 miles from Auckland, a hole was bored to a depth of 945 feet, at a cost of £105, exclusive of coal; and at Huntly, a hole, 145 feet deep, was bored in 1½ days, through quicksand and 30 feet of coal. The best record, however, was through alluvial at Turua, Thames Valley, where a hole, 3 inches in diameter, was bored to a depth of 214 feet in 6 hours, 74 feet of which was done in 1 hour. In each instance, 8 hours constituted a day's work, the labour attending the machine being

a man, and a lad, 19 years of age. The whole of the gear, including engine and boiler, but not including the derrick-pole, is mounted on a wagon, and can be easily removed on level ground by two horses. It takes about 4 hours to set up the machine ready to commence boring.

Fig. 1 shews the general arrangement of the machine. The pump, fixed on one side, is worked from a disc on the end of the main shaft. The suction-pipe disappears at the left-hand of the picture. The delivery-pipe to the rods come away overhead to the downward bend on which is fixed a flexible pipe, and in the picture this comes down nearly to the ground, forming the letter U, and disappears out of the top of the picture, where it connects on the pipe-rods. The overflow of water, etc., from the bore-hole is carried through the horizontal pipe a little above ground-level, and is delivered into the trough used as a settling-tank, so that the water can be used over again when it is not handy to get supplies. A fine sieve is kept under the pipe-end to collect samples of the boring. The engine has a cylinder $4\frac{1}{2}$ inches in diameter, by 8 inches stroke.

To obtain an accurate section of the strata, skill in handling the machine is essential; and when plenty of clear water is obtainable, an accurate section is procured, but when the water has to be circulated, the changes are not so easily marked.

Although this particular instance of the use of a bore-hole for pumping water is only on a small scale, the writer is of opinion that there are many instances where a bore-hole might be used to advantage, and long ranges of pipes dispensed with. He further holds the opinion that probably there are instances when it might be advantageous to put down two holes, one for water and the other for steam, and by placing a boiler at the top of the holes a long transmission of power by some other means underground would be obviated.

As previously stated, this paper is not prepared as a record of an engineering feat, but merely to shew what in actual practice one is sometimes by force of circumstances led to perform, and the writer hopes that it may prove of interest to many of the members.

Mr. FRANK COULSON (Durham) wrote that communication between the surface and underground workings by means of bore-holes is of considerable importance, either for the delivery of water as adopted by Mr. Wight, or for conveying power: whether compressed air or electricity. The air-compressors may be placed on the surface at the top of the bore-hole and driven by electricity generated at any suitable point, probably at the colliery, thus saving the great length of tubes frequently necessary to convey compressed air to the working-face. By this method, also, electricity might be conveyed into fiery mines to a power-station, and thus obviate the danger of conveying the current by wires underground. Probably it would be necessary to enclose the underground power-station, and force air down the bore-hole, so as to prevent any gases or air from the mine from coming near the motor or the short length of electric wire in the mine. Bore-holes might also, in some cases, be used to drain gas from old workings. An argument against the use of such bore-holes is that they might possibly be damaged by the movement of the ground caused by the working of the coal.

The PRESIDENT (Mr. W. O. Wood) moved a vote of thanks to Mr. Wight for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. M. WALTON BROWN read the following description of "The Neu-Catrice Portable Electric Lamp for Miners":—

THE NEU-CATRICE PORTABLE ELECTRIC LAMP FOR MINERS.

This lamp (Fig. 1) consists essentially of a box or case of sheet-lead containing two accumulator-cells made of transparent celluloid or semi-plastic indiarubber. Each accumulator contains one positive and two negative plates of the Etampé type. The united elements constitute a small battery of a mean voltage of 3·9 volts, sufficient to supply, for 15 consecutive hours, a small incandescent lamp with a constant illuminating-power of about 1 candle. In order to avoid the spilling of the liquid, the electrolyte of these accumulators is fixed by a special process, in such wise that the lamp may be used without risk in any position whatever.

On the lid of the case is fixed an ebonite-base which supports a protecting globe of extremely thick glass, and within the thickness of the ebonite-base a small opening is cut to allow of charging the cells. A small movable shutter masks this aperture, and is so combined with a switch that the lamp can only be lighted when the charging-plug is withdrawn and the shutter is closed. This arrangement is adopted with the view of preventing the current for charging the accumulators (which is at a minimum potential of 5 volts) from being passed through the lamp.

Fig. 1.

The lid of the case is locked by a leaden rivet which can be impressed with a stamp, so as to ensure it against being idly tampered with by persons who are not entrusted with the duty of keeping the apparatus in order.

Upon the ebonite-base is also fixed a socket to carry the end of the bulb of the small lamp. The upper portion of the protecting-globe is held fast (with the interposition of a rubber ring) by a cover, and the latter is connected with the lid of the sheet-steel case by three pillars or poles, and, finally, a hook rivetted to the upper part of the steel cover completes the lamp. The protecting-globe is, in regard to one half, painted with a semi-translucent white

varnish which acts as a reflector, while allowing a certain amount of light to be diffused backward.

This portable electric lamp is made in two sizes: one weighing 3 pounds 14 ounces, gives 0·8 candle-power during 11 hours, and the other weighing 5 pounds gives 1 candlepower for 15 hours. The respective dimensions are, for the small lamp: 10 inches high and 2⅜ inches square; and for the big lamp: 10 inches high and 3 inches square. The lamp consumes less than 3·5 watts per candle-power and lasts for 500 hours.

The charging-plug consists of a block of ebonite, which bears on one of its faces two brass springs; and this arrangement is so devised that any possible error in polarity is obviated.

To recharge the lamps a charging-table consisting of 20 or 40 compartments is used, according as the available electromotive force is 110 or 220 volts; and a small switchboard comprizing a regulating rheostat, an ammeter, a minimum cut-out, a two-ways commutator, and a 32 candlepower lamp used as a resistance, absorbing at the commencement of the discharge the excess of voltage which would rapidly deteriorate the small lamps. When the accumulators are recharged, before removing the charging-plugs they are discharged for 20 minutes on to the 32 candle-power lamp upon the switchboard.

Above each compartment is the charging-plug, fixed to one of the ends of a pliable cord with two leads; the other extremity of this cord is attached to the two-ways commutator. In this manner the current may be either sent through the plugs, or diverted through a resistance, equivalent to that of the accumulators, coiled round the base of this very commutator; this arrangement allows of the recharging of any given number of lamps, the current intended for those which are not at hand being absorbed by the corresponding resistances.

The charging-current should be of 1 ampère, and the duration of charge about 12 hours. The lamp is kept in the lamp-room from the time when the workman comes to bank (2 p.m.) until he calls in to fetch it away again the next morning (5 a.m.). For a load of 500 lamps a shunt-wound dynamo of 110 volts and 25 ampères capacity is required.

The lamp is closed by means of a leaden rivet, and the lid should only be raised every four or five days, in order to pour a few drops of acid into the cells. The shutter which masks the

charging aperture is also closed by a leaden rivet: and it is taken off daily for purposes of recharging.

TABLE I.—EXTRACT FROM THE REGISTER OF THE LAMP-ROOM AT No. 1 PIT OF THE BRUAY COLLIERIES, PAS-DE-CALAIS.

Daily mean during April, 1903.

		Per cent.
Number of lamps in good working order	504	
Number of lamps taken down the pit daily	504	
Lamps, which have completed the shift		96·73
Lamps unusable :—		
For want of voltage		0·72
Worn-out bulbs		1·52
Defects in switches		0·07
Defective connections		0·72
Unspecified accidents		0·24

For the past 15 months, 500 of the larger sized lamps have been in use at No. 1 pit of the Bruay collieries, and the annexed table will enable the members to form some idea of the good results which have been achieved. The cost of maintenance amounts to almost exactly ½d. per diem.

The PRESIDENT (Mr. W. O. Wood) stated that while he was not familiar with the Neu-Catrice lamp, he had in regular use at Murton colliery, some 1,400 Sussmann portable electric lamps. This style of lamp presented considerable advantages, as it was absolutely safe in gaseous atmospheres and very reliable. The bulbs had a life of about 700 hours. The cost was about 3s. per lamp per annum more than that of the ordinary oil-lamp, but he thought it was quite worth while to pay this amount if it was only in the shape of an insurance against explosion, and in fiery mines it was an immense advantage to have a lamp of this description.

DISCUSSION OF MR. W. LECK'S PAPER ON "AMBULANCE-INSTRUCTION AT MINES."*

Surgeon-Major GEORGE A. HUTTON (Honorary Organizing Commissioner of the St. John Ambulance Association) wrote that when the final report of the Royal Commission appointed to inquire into accidents in mines was issued in 1886, he was deputed

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 354.

by the St. John Ambulance Association, to conduct an Ambulance Mission in the counties of Durham and Northumberland. His first meeting was held at Bishop Auckland, with the then Bishop of Durham (Dr. Lightfoot) in the chair, who said that "he felt that he was assisting in a work of great beneficence and usefulness, and he hoped that classes would be formed in every colliery-village throughout the county." He (Mr. Hutton) said that no doubt that ambulance-instruction interwoven into the daily life in all mining villages, would add brightness, kindness and active benevolence to that life—it would tend to sweeten life—to make it more endurable—more hopeful—more Christian in all the centres of toil and industry. He then recommended that classes of 30 men should be formed at every colliery. The result of this meeting was that a very large number of classes were started all over Durham county in 1887; and as an outcome of these classes, a large gathering of some hundreds of ambulance-men, who had undergone instruction, was held in October, 1888, in Beamish Park, county Durham, when various ambulance-evolutions were gone through.* He said at the close of the drill, in congratulating the men on the practical way in which they had shown their ambulance-knowledge, that we had established hospitals for the sick and injured all over the country—we had also in several places started convalescent homes, and in some few places homes for the incurable; but there was still one more link to complete the chain of assistance to the injured—a link which, if omitted, led to much pain and suffering, and that was this ambulance-link, and he invited all to assist in forging this link, and in doing so, to make it a lasting and durable link—in short, a permanent work among them.

He hoped, therefore, that Mr. Leck's paper might largely assist in reviving the classes throughout the mining districts of the country. He had always found it most desirable that the syllabus of the lectures issued by the St. John Ambulance Association should be strictly followed, and five lectures were quite enough, especially for miners, with perhaps an additional lecture summarizing the course, given a week after the last lecture, and previous to the examination.

With regard to Prof. T. Oliver's remarks on accidents from electricity, he represented this matter to the central committee

* *Illustrated London News*, October 20th, 1888.

in London some time ago, and he had been told by the chief secretary of the St. John Ambulance Association (Sir Herbert Perrott, Bart.) that an addition to the syllabus referring to accidents from electricity would be added.

The best time to commence the course of instruction is in October or the beginning of November, so as to get the course over before Christmas, or if more convenient, after the Christmas holidays in January and February, so as to hold the examination not later than April or May. The summer he had always found better devoted to outdoor ambulance gatherings in the form of demonstrations of work and competitions. The main object of the instruction should be to make the work practical, and there were about five cardinal points that he might emphasize: —(1) Broken bones; (2) arrest of bleeding; (3) burns by fire; (4) drowning, and the accidents likely to occur in the industries of the various districts where the instruction was given, such as noxious gases, electricity, etc.; and (5) the careful removal of the injured by hand, on stretchers, in horse-ambulances—by road, by railway, etc.

As far as the mining districts of Great Britain were concerned, as a general rule, he considered that the system of detached classes would be found most convenient. Mines being studded all over the county, the classes could be more easily managed in this way by direct communication with London, and having visited a large number of these mines in past years, he could speak with some authority on this part of the work.

In the opening sentence of Mr. Leek's paper the author said that "ambulance-instruction at mines may, at first sight, appear to many persons as having but a remote connection with the specific business"* of the members, but looking at it as an economic question, apart from humanity, there was no doubt that carried out on practical and systematic lines, it would lead to (1) reduction in the death-rate in mines, (2) reduction in sickness and injury, and length of time on the sick-list and (3) the saving of the funds of all societies formed for dealing with mining distress caused by accident. Considered in this light, Mr. Leek's paper was well worth the careful attention of the members, and it was to be hoped that a large number of ambulance-classes would be started at collieries and mines in the forthcoming winter.

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 354.

Mr. WILLIAM LECK (H.M. Inspector of Mines, Cleator Moor) wrote that Mr. A. H. Stokes (H.M. inspector of mines for the Midland district) stated in 1888, that ambulance-instruction had obtained a substantial footing in his district. At that time there were in the Midland district 2,924 persons either undergoing a course of instruction or already qualified to render first aid to the injured.*

The practical remarks of Surgeon-Major Hutton, drawn from the experience of a long and busy life, deserved the careful consideration of every one interested in the promotion of ambulance-work. He agreed with him that, as a general rule, colliery-classes could be best administered by means of detached classes. The weak point with reference to centres was that an apparently strong organization might suddenly collapse, if the prime-mover in the matter dropped out of the work. This regrettable result, the Chief Secretary of the St. John Ambulance Association had not infrequently had occasion to deplore, but it was counteracted when the classes were in direct communication with head-quarters. On the other hand, an aggressive centre would, in his opinion, do more missionary and extension-work than any other form of organization which had yet been tried.

He took this opportunity of correcting a slight error in the foot-note on page 370,† where the fifth line should read "to which the officials of the Whitehaven Colliery Company." This did not affect the deduction, immediately following, and it had been a source of supreme satisfaction to him that the ambulance-movement in West Cumberland had been the means of bringing together employers and workmen in harmonious unison, for the furtherance of one common and highly commendable object, the alleviation of human suffering.

DISCUSSION OF MR. W. M. BREWER'S PAPER ON "THE ROCK-SLIDE AT FRANK, ALBERTA TERRITORY, CANADA."‡

Dr. EUGENE HAANEL (Superintendent of Mines, Ottawa) wrote that the summary of the official report on the recent land-slide at Frank, Alberta, by Messrs. McConnell and Brock, was as follows:—

* *Annual Report*, 1888, page 5. † *Trans. Inst. M.E.*, 1903, vol. xxv.

‡ *Trans. Inst. M.E.*, 1903, vol. xxvi., page 34.

As to the nature of the disaster at Frank there cannot be a doubt. It was a rock-slide (Bergsturz) of colossal dimensions, one of the largest on record.

Turtle Mountain, part of which fell away, is a sharp Rocky Mountain ridge, which, with the exception of a short talus-slope at the base, rises very steeply in a succession of cliffs, to a height of 3,100 feet above the valley. It is the central and highest peak of this ridge, which broke away. The mountain consists of Cretaceous sandstone or shales at the base, with limestone (part at least of Devonian age) forming all the upper portions. The limestone has been thrust over the newer rocks along a fault-plane by the mountain-building forces. The Cretaceous beds are overturned, dipping into the mountain at an angle of 82 degrees, while the limestones have a westerly dip of 50 degrees. The basal beds of the limestones have been much folded and crumpled by friction, due to thrusting forward of the series along the fault-plane. They form a very weak base for the precipitous mass above. The mountain is thoroughly dissected by fracture and jointing-planes.

On the morning of April 29th, 1903, a mass of rock surrounding the central peak, ½ mile square and 400 or 500 feet thick, suddenly broke away and rushed with great velocity into and across the valley, destroying everything in its path. Fortunately, the greater part of the town lay outside the course of the slide, but much property was destroyed and 70 lives were lost. Over 1 square mile of pleasant valley was transformed into a dismal waste of rock.

The motion of the slide-rock was complex in detail, but as a whole resembled that of a viscous fluid. The distance from the top of the break to the foot of the slide, following the slope, is about 2½ miles. The average thickness of the slide-rock across the valley, along the centre of the slide, is 65 feet; the deepest portion of the slide is about 150 feet thick, and the average over the whole slide cannot be less than 45 feet. A rough estimate of the amount of material dislodged is about 40,000,000 cubic yards, representing in weight about 90,000,000 tons.

In the Alps, destructive land-slides have been quite frequent, but are exceedingly uncommon in the Canadian Rockies. None at all approaching this one in size has ever been recorded.

The slide was due not to a single cause, but to a combination of causes. The primary cause was undoubtedly the form and structure of Turtle Mountain, already referred to. The huge mass was in a state of unstable equilibrium, possessed a weak base, and was thoroughly traversed by fissure and jointing-planes, in which water and frost were continuously at work removing, one by one, the supports which held it in place. The heavy precipitation of the last few years accelerated this process. Recent earthquake-tremors, particularly that of 1901, no doubt hastened the time of final disruption. The opening up of large chambers in the mine, situated under the base of the mountain, may have been a contributary cause, by allowing slight readjustments in the strata forming the hanging-wall of the seam, producing jars that might dissever some of the few remaining bonds. The heavy frost on the morning of the slide, which followed hot summer-like days, appears to have been the force which severed the last thread and precipitated the unbalanced mass.

The zone, surrounding the cavity left by the mass which broke away, is excessively fractured and is doomed to fall. The portion behind the break

and south of it is not dangerous, as it has a free course and is already falling in small individual blocks. The north peak and shoulder overhanging the town are, however, dangerous. They threaten the town and the mouth of the mine. Their condition now is very similar to that of the central peak before it fell away. There is always a remote possibility of a sudden movement, although the commencement of the movement is more likely to be gradual. In course of time, ordinary atmospheric weathering will bring down this threatening mass, but a slight earthquake-shock, a succession of seasons with unusually heavy precipitation and rapid temperature changes, or the closing of the chambers in the mine, after the coal has been "drawn," perhaps long after the inhabitants of the town have lost all dread of any impending disaster, may precipitate it suddenly in a second destructive slide.

Since this possibility must always overhang the town, it certainly seems in the interest of safety that it be moved a short distance up the valley, beyond the reach of danger.

Mr. W. D. L. HARDIE (Lethbridge, Alta., Canada) wrote that he visited Frank, some two or three days after the disaster, and the rumbling rocks, even then, created a noise and roar that was simply appalling; and the great clouds of dust made the spectacle more wonderful.

He had a long conversation with Mr. D. M. McKenzie and others of the 17 miners, who were entombed; and they all practically gave the same statement, as Mr. McKenzie, which had been reproduced in Mr. Brewer's paper. He thought that Mr. McConnell's estimate of about 90,000,000 tons of rock was a very modest one. He had seen statements running as high as 200,000,000 tons, and would not say that even these large figures exaggerated the extent of the slide. The immensity could not be conceived or imagined without a visit.

The members might form an opinion as to the cause of the disaster if they more fully understood the method of mining adopted there, and the relation of the seam being worked to Turtle Mountain. Fig. 1 (Plate IV.) gives an idea of the method of mining, and Fig. 2 (Plate IV.) shows the relative positions of the mine and Turtle Mountain. Fig. 3 (Plate IV.) is a section of Turtle Mountain, showing approximately the portion of the mountain that slid into the valley. The coal-seam does not run into the mountain, but strikes nearly parallel with it, the cover becoming thicker as the mine advances in the seam. At 5,000 or 6,000 feet from the mine-entrance, the seam extends several hundred feet above the day-level, while there is very little cover at the mouth of the level.

Since the disaster, the Canadian-American Coal and Coke Company have done a little work at the old mine; they have put in a day-level at the opposite side of the valley, and they have sunk a shaft in the coal at B (Fig. 2, Plate IV.). At the time of the slide the Company were shipping about 800 tons per day of run-of-mine coal. It is a matter of conjecture as to whether the Company intend to resume work in the old mine permanently, or only to draw off the loose coal that had accumulated during the process of mining.

The seam, 12 feet thick and lying at an angle of 82 degrees, had been developed by a pair of gangways or levels, 9 feet high and 12 feet wide, driven in the seam and spaced 30 feet apart, one above the other, with holings at intervals of 60 feet. Vertical chutes, 5 feet by 5 feet, are driven from the upper gangway to the rise, at intervals of 25 feet, and at a height of 30 feet, a breast, 175 feet wide, is driven to the rise, containing seven room-chutes, 5 feet by 5 feet, lined with timber, 3 inches thick and 12 inches wide. A travelling-way, 4 feet by 4 feet, is driven on the hanging-wall, at each side of each breast of work. A rib of coal, about 34 feet wide, is left between the breasts, and the manway, 4 feet by 4 feet, is driven in the middle. The only coal, up to the present time, shipped from the breasts is that due to the increase in the bulk of loose coal over that of solid coal *in situ*, and represents about 33 per cent. of the coal mined in the breasts (Fig. 1, Plate IV.). The mine is ventilated by a forcing fan placed on the inlet-gangway, and the air leaves the mine by the return level.

Mr. ALEXANDER FAULDS (Vancouver Island, British Columbia) wrote that had this disaster, which happened about 4·15 a.m., occurred in the day instead of at night, the loss of life would have been much greater, as a considerable force of men would have been engaged in and about the mine-mouth, erecting buildings and a new tipple, and installing an electric-light plant, all of which were completely destroyed.

The valley, about 1 mile wide, lies between Turtle Mountain and the foot-hills of a rocky range of mountains to the north. The Old-man river flows through the valley (Fig. 2, Plate IV.), close to the foot of Turtle Mountain, and the mountain-wall is so high (Fig. 1, Plate IV.) that on the longest day in summer the sun sets in the town at 3 p.m.

The coal-mine extends along the side of Turtle Mountain in a parallel direction. The mountain fell away immediately over the workings, burying the entrance to a depth of more than 100 feet. Part of the debris of the mountain crossed the valley to the foot-hills on the opposite side, converting cosy homes and valuable property into a waste. Between the two peaks of Turtle Mountain, a huge semi-circle had been gouged out, extending downward from the top almost to the foot.

In the early morning, a great cloud which changed to a deluge of rocks, mud and debris poured down the rugged slopes of the mountain, damming to a depth of 40 or 50 feet the Old-man river, and the water passed into the gangway of the mine, flooding it for several feet in height.

The mine was situated directly in the path of the slide; and the section (Fig. 1, Plate IV.) gives an idea of the mode of working and the contour of the mountain at this point.

Two miles of the Canadian Pacific railway were buried under many feet of rock, necessitating the locating and building of another line.

Mr. Daniel M. McKenzie, one of the entombed miners, stated that the top of his place moved in bodily from 1½ to 2 feet. There was indication of a squeeze, chute and entry-timbers being badly broken, but there was not any serious damage done in the mine beyond the first 100 feet at the entrance. The imprisoned miners dug 30 feet across and 9 feet upward in soft material to their liberty, while rescuers, from the outside, also worked towards the imprisoned men. Fortunately, just above the mine-mouth there was a bare perpendicular face of rock about 50 feet high; this had not come down with the slide, and the chute, which it formed by its curve, threw the rocks outward some distance beyond the entrance to the mine. Only a little of the debris which came down in the first great rush, killing a driver and a trapper at the tunnel-mouth, fell over the mine-opening.

Mr. A. J. Hill (New Westminster, British Columbia) wrote that no one, acquainted with the geology and surface-characteristics obtaining throughout the mountainous regions of British Columbia, was deceived by the first sensational reports of volcanic outbursts or gas-explosions as the moving cause of

the catastrophe. The frequent occurrence of similar rock-slides everywhere along these great canyons both in modern and prehistoric times, was sufficient evidence that the startling news from Frank indicated but one more added to the list. Sections across the canyons show intermittent rocky precipices from several hundreds to some thousands of feet in height, composed generally of highly metamorphosed material, deeply fissured and shivered into incoherent fragments, waiting only for a season of extra precipitation and the resulting tremendous bursting force of crevices surcharged to an unusual level, to precipitate the cataclysm and hurl the whole disintegrated mountain-face into the valley below.

He (Mr. Hill) was a witness of one gigantic slide, in this case of earth (but no doubt due to like causes) which brought down some hundreds of acres of cultivated fields, forcing the mass, with ½ mile of frontage across the Thompson river (a rapid stream 500 feet in width and of ample volume), and holding it in complete check for 42 hours and to a height of 120 feet, and flooding the lower lands up-stream for 10 miles. The Grand rock-slide, 90 miles above Yale, which closely approaches that at Frank in magnitude is a case in point, dating from prehistoric times for the greater portion of its volume; but it continues to send down an occasional boulder as evidence of the forces still unexhausted.

To the disintegration of the rock generally and the creation of a head of water of great bursting power behind the shattered masses, may probably be attributed the ultimate cause of nearly all these slides, whether of earth or rock, and, as long as these great canyons exist, the mountain-regions can never be free from such slides.

Mr. G. F. Monckton (Copper-creek Mines, Savonas, British Columbia) wrote that this catastrophe was undoubtedly due to the removal of the coal-seam which formed a natural support to the foot of the mountain. The seam had been practically all worked out for a length of over 3,000 feet, up to a height of 300 feet above the level of the floor of the valley. Some of it was still stored in the workings. Pillars, 20 feet wide, were left between the rooms. The output averaged 600 tons daily, and had attained 1,000 tons. As the Carboniferous Limestone,

To illustrate Discussion on "The Rock-slide at Frank" etc.

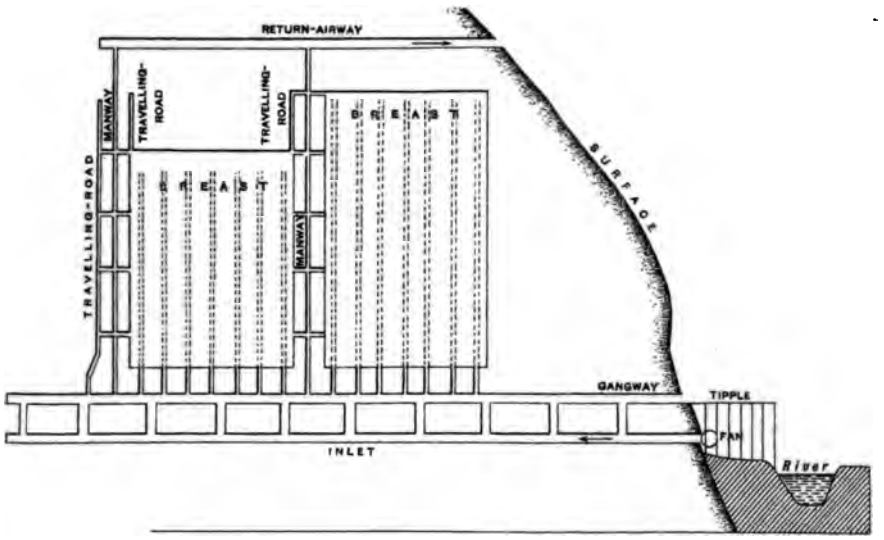

FIG. 1.—SECTION OF MINES AT FRANK.

Scale, 200 Feet to 1 Inch.

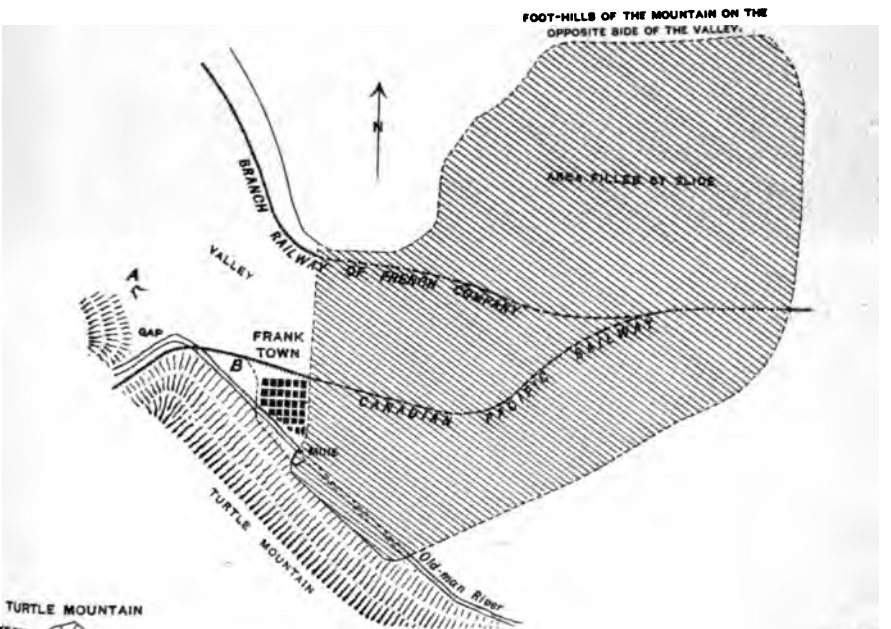

FIG. 2.—MAP OF REGION ABOUT FRANK.

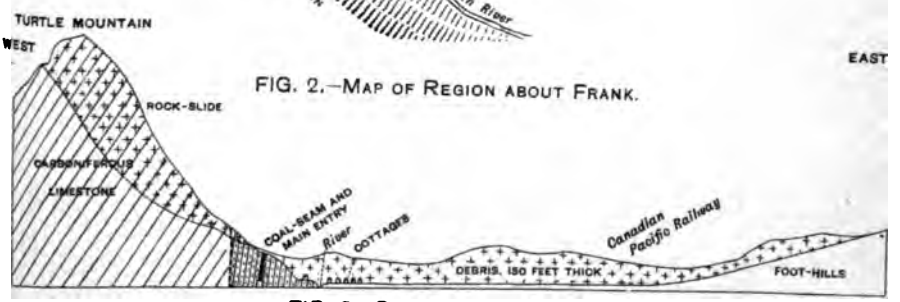

FIG. 3.—SECTION OF ROCK-SLIDE.

which towered over the coal-seam, and formed Turtle Mountain, dipped at an angle of 40 degrees into the hill, it was only a question of time when nature would take steps to fill the vacuum thus created. It must be noticed that there had been a squeeze in the mine, masses of rock had become detached from the wall nearest the mountain, and had fallen into the workings some time previously. After the first fissures had opened on the mountain, due to the movement of its face, which sloped in some places at an angle of 60 degrees, ice would collect in them and exert great pressure to accelerate the movement, especially in the spring when it would be alternately thawing and freezing. Without going into deep calculations, the mere fact that water expands 9 per cent. in freezing will show this, and those who have travelled among high mountains in spring will have had sufficient experience of the effects. It would seem impossible to work this mine with safety unless a system of filling were adopted; and this might perhaps be feasible, as the material could be taken from ground above the outcrop.

DISCUSSION OF MR. W. E. WALKER'S PAPER ON THE "HÆMATITE-DEPOSITS AND HÆMATITE-MINING IN WEST CUMBERLAND."*

Mr. H. D. Hoskold (Buenos Aires) wrote that, in his opinion, the subject of iron-ore deposits, some of which had partly been noticed in the paper of Mr. W. E. Walker, was exceedingly interesting and important, and if other members with sufficient leisure were to follow with other papers upon all the more important iron-ore districts of Great Britain, going more into detail as to productive qualities, cost of development, probable profit to be derived and duration, great service would be rendered to the iron-smelting industry and others depending thereon.

The majority of rich hæmatite-mines of the Forest of Dean, had, for want of sufficient capital to sink to greater depths, been abandoned; but not before it was proved that on the eastern side of the basin, the deposits of hæmatite, over a distance of 3 miles in length, or more, were as extensive and rich in the deep workings as they had been near the surface. Doubtless, the abandonment was due to the scarcity of ore-deposits and the high cost of extract-

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 292.

ing the mineral from deep workings, and other mining districts would, in the near future, have to be abandoned for a like reason. It would, therefore, seem to be necessary to make further explorations in promising districts, for, at present, it would appear that the time is fast approaching when iron-smelters will have to depend for their supplies of iron-ore upon foreign countries. Mr. Walker seemed to make it clear that the best days of Bilbao hæmatite-mining had passed, and it was highly probable that other similar deposits do not exist in any accessible place in Spain or probably, in any other country under such favourable conditions as would leave a sufficient margin of profit to the British smelter. Nothing could prove so injurious to the general prosperity, stability, commercial relations, and domination of the British Empire, as a continued decline in the iron- and steel-trade, and coal-production. Consequently, it is absolutely necessary that some stringent economic and legislative means should be adopted to preserve the resources of the coal-fields beyond the 300 years estimated period of duration, in order to maintain home-manufactures, commerce, and British supremacy.

Referring to the Cumberland iron-ore district, when the mineral occurred near to the surface, the yield was greater, and the extraction less costly than when extracted from greater depths. According to Mr. Walker's showing, two of the four deposits he enumerated, that was, the upper ones, were represented to be nearly exhausted; but he estimated that the two lower deposits of hæmatite "extend over a considerable area" and may consequently yield a large quantity of hæmatite. He also stated that "the No. 4 bed is found lying on the slate-rock or on a calcareous limestone."* This remark would seem to indicate the presence of the Silurian formation and the absence of Devonian rocks.

Prof. John Arthur Phillips stated that "the red hæmatite from the vicinity of Whitehaven in Cumberland, and of Furness in Lancashire, is obtained either from Carboniferous rocks or from those of Silurian age. Practically, however, it is almost entirely derived from the former, since the deposits in the Silurian rocks are of extremely limited extent. The Carboniferous Limestone series, in which the principal deposits occur in both districts, consist mainly, as before stated, of alterna-

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 295.

tions of limestones, with shales and sandstones."* The facts of borings having been made, and that pits were in course of sinking down to 1,200 feet in depth, would seem to indicate that newer discoveries have been made in the lower series of the hæmatite-deposits.

Mr. Walker referred to the big winding-engines and pumping machinery employed at pits of less depth; but nothing was said with reference to the class and cost of the machinery required at the deeper workings, nor of the amount of water expected, nor of the extra cost per ton of mineral raised. It was to be regretted that such omissions had been made in the paper, because a scale of cost for plant and for the extraction of the hæmatite from shallow and deeper workings would show approximately their comparative value, and how far the deeper explorations could in all probability be profitably carried on, as also, the time estimated when the Cumberland iron-ore districts would cease to be worked.

The remarks of Mr. J. D. Kendall upon Mr. Walker's paper, did not encourage the hope that the best days of Cumberland hæmatite-mining were yet to come; on the contrary, he seemed to prove that the produce of the mines was on the decline, at the rate of about 50 per cent. in the space of 20 years, so that according to this estimate, and in the absence of other important discoveries of hæmatite, mining in the vicinity of Whitehaven, that is, the hæmatite-district, would most likely be closed in less than 20 years.

Many years since, he (Mr. Hoskold) had the inspection of hæmatite-mines situated at Lamplugh; but, previously, the greater part of the iron-ore had been extracted. The machinery and pits were in a deplorable condition, and after some explorations had been made and a small quantity of hæmatite extracted, he declined to continue his periodical inspections. A particular examination of the journal of the borings which had been made upon the Lamplugh mining estate proved that no important deposits of iron-ore had been struck, sufficient to warrant the expenditure necessary for erecting new machinery and sinking other pits. The journal in question did not indicate that the borings had been carried deeper than the upper limestone-beds, in which it is generally believed that the

* *A Treatise on Ore-deposits*, 1884, page 160.

most important deposits of hæmatite occur. If the lower deposit referred to as No. 4 bed by Mr. Walker, and as resting upon the Silurian rocks, exists under the Lamplugh estate, further borings would have to be made to prove its extent and value.

Mineral-veins occur in various rock-formations, and the study connected therewith is very important; but it would be out of place in a discussion of this class to go over the various theories propounded in standard works upon the subject. Occasionally, however, opinions are emitted which do not appear to fit in with all the circumstances and conditions so frequently presented to the engineer for solution. It was difficult to believe that the hæmatite-deposits found in the Carboniferous Limestone in various parts of England were not formed in the same or a similar manner. Upon this point Mr. Cedric Vaughan said: "If, as Mr. Kendall suggests, this salt of iron came from below in a gaseous condition through the then recently-formed faults in the Carboniferous Limestone, and coming into contact with water formed a solution of perchloride of iron, then, as he has shown, the whole of the facts become simple and easily understood by the chemical formula which he gives."* A good deal was intimated in the passage quoted; but very little proved. And we must remember that in a chemical laboratory it is easy to produce any such reaction as may be desired to assist in the formation of a theory; though similar reactions in nature's laboratory are more difficult to be understood, because the restrictive principles in each case are different, and he (Mr. Hoskold) thought that the theory proposed and referred to by Mr. Vaughan, did not fit in with all the circumstances and conditions under which all hæmatite-deposits occur.

Referring to that well-known and extensive hæmatite producing district, in the past, that was, the Forest of Dean, for some curious evidence, he might state that on the eastern side of that mineral basin, it had been proved that for a distance of about 5½ miles along the outcrops of the iron-ore, or from the Howbeach valley southward to the Westbury brook iron-mine, northward, near to Mitcheldean, no evidence exists that the limestone-measures have been disturbed by faults, and, therefore, the assertion of Mr. Walker "that if there were

* *Trans. Inst. M.E.*, 1903. vol. xxv., page 298.

no faults, there would be no hæmatite-ore, because there would have been no spaces in which iron-ore could have been deposited "* is not correct in this case. In the district just referred to, a large number of exceedingly extensive deposits of hæmatite occurred, separated one from the other by solid bars of rock of considerable length. These deposits of iron-ore rest upon a bed of fine-grained crystalline limestone, locally called the "Underedge." Each of these deposits generally has a thickness of 30 to 40 feet, that is, extending laterally from the Underedge limestone to the contact with another well-marked bed of limestone, called the "Lid," or cover of the iron-ore measures. In a word, generally speaking, no iron-ore of importance occurs below the Underedge limestone or above the Lid limestone. The dip of the Underedge is from 70 to 75 degrees, and its strike about south 35 degrees west, and north 35 degrees east. When each deposit of hæmatite has been extracted from the exploring heading or water-level upwards or to the rise, to meet other older workings, an immense cave is left in each case, having a rugged water-worn appearance. Many of these caves exist at the surface and extend downwards at the rate of dip named, for a great distance, or to the lowest exploring heading that has been made. The deposits of iron-ore are not situated one above another vertically in the limestone, as generally seems to be the case in the hæmatite-mines of Cumberland; but upon the same zone, or Underedge limestone, and, as previously noticed, they occur in succession as the exploring tunnel or level-heading advances in the direction of the strike of the Underedge limestone, and upon it. The dip of the hæmatite-deposits is generally at right angles to the strike. Upon rare occasions, a few of the deposits of iron-ore have been known to terminate in the deeper workings, and when this is the case the lower part of the Underedge limestone gradually rises from its usual amount of dip until it is in contact with the Lid Limestone. The termination of the cave downwards presents the form of the thin edge of a wedge. The reverse of this has been known to occur, that is, at the deepest exploring heading in one of the mines, a deposit of hæmatite occurred upon the Underedge limestone, and extending along the strike of it for 900 feet, filling the entire measures, or 40 feet in thickness. But it is

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 296.

very curious to observe that this deposit of iron-ore extended only a few feet upwards upon the rise or above the water-level. It was, therefore, a new deposit extending under the water-level, but to what depth is unknown. There were no indications at the surface-outcroppings that this deposit existed in depth. The iron-ore measures, or bed of rock containing the great deposits, and existing between the Underedge limestone and the Lid limestone, is of a reddish colour, and is a coarse-grained limestone, locally called "Crease," and totally different from all the other beds of limestone. It is this particular bed of rock which, according to the theory (noted by Mr. C. Vaughan), must have been removed or displaced in certain places by some local influence, and so formed depressions or caverns in it in various confined localities before the hæmatite was deposited. It is very curious to note that such depressions or caverns are sometimes filled with indurated brown mud or clay, instead of iron-ore. Here, again, it should be noted that Mr. Walker's expression "because there would have been no spaces in which iron-ore could have been deposited" is not supported by facts. In the whole district referred to there is no evidence that gaseous emanations came from below, and combining with water produced the action referred to by Mr. C. Vaughan. If the Crease limestone was originally displaced by some dissolving or corrosive solution, such as that suggested, and so formed the depressions or caves noticed, some other agent or special conditions must have been present at the same time to confine the dissolving solution to certain particular places or limited areas, that is, the hollows in which the hæmatite was deposited. Otherwise it is natural to suppose that if the corrosive solution had existed in quantity and been continuous, the entire area of the Crease limestone must have been exposed to its influence and must have been affected: that is, the adjacent parts of the limestone surrounding the excavated parts or hollows, being of the same nature, would also have been liable to displacement. It has never been discussed whether the hollows in the Crease limestone were made and filled with hæmatite-ore before the Lid limestone was deposited, or afterwards; or before, or after, the Limestone-measures were tilted to form a dip of 70 degrees.

If the theory of Mr. Kendall, and apparently endorsed by Mr. Vaughan, were true, it would seem to be anomalous that

when the Crease limestone had been displaced, the hollows so formed were filled with clay instead of iron-ore. This particular circumstance does not favour the idea enunciated by Mr. Walker that "there would have been no spaces in which iron-ore could have been deposited;" nor the theory of Mr. Kendall as to the particular mode or cause of the deposits of iron-ore in the Carboniferous Limestone.

However, the same conditions in the same district do not always exist, as he (Mr. Hoskold) would now endeavour to show. On the western side of the Forest of Dean mineral-basin, previously referred to, and at a distance of about 1½ miles from the town of Coleford, in a south-westerly direction, many excavations have been made in the Carboniferous Limestone, presumably by Roman miners, and to a considerable depth. Evidence is presented to-day that these old miners extracted large quantities of iron-ore, and they frequently holed into natural caves of immense size also presenting a rugged water-worn appearance. By penetrating into the old Roman workings, these natural caves, which are numerous, may still be inspected. There is no appearance that iron-ore ever occurred in these caves; but it was sufficiently abundant to the rise and to the dip of them. If these natural caves had been formed upon the principle, advanced in the theory of Mr. Kendall, they should have been filled with iron-ore, and extracted, as in other cases, by the Romans. It is, however, known that these natural caves are connected to a lower drainage level, and this has been urged as a reason why the natural caves were not filled with iron-ore. He (Mr. Hoskold) had seen similar phenomena in the limestone-mountains in the province of Santander, Spain. In the blende and calamine mining-districts there, natural caves of immense size are found in which, from the stalactitic appearances, zinc-mineral could never have occurred.

Considering all the difficulties connected with the origin of the materials which formed hæmatite-ore, and the particular manner of its deposition, he (Mr. Hoskold) was not prepared to accept the theory referred to by Mr. Vaughan.

Mr. J. D. Kendall (London) wrote that Mr. Hoskold was clearly not acquainted with the district under discussion nor with the principal features of its ore-deposits. The substitu-

tional origin of the West Cumberland deposits was, as he (Mr. Kendall) had elsewhere shown, a geological necessity and was quite independent of the particular chemical process by which it was carried out. The caverns existing in the district are much more recent than the ore-deposits and their presence does not affect his (Mr. Kendall's) explanation in any way. They had been formed by simple removal of limestone, and not by a substitution of hæmatite for that mineral.

Mr. W. E. Walker (Whitehaven), with regard to those deposits which, owing to their being to the dip, are found at a great depth, wrote that much larger capital is necessarily required for the sinking and providing of plant than was the case, many years ago, when sinking to Nos. 1, 2 and 3 beds, which were found at, comparatively speaking, shallow depths; although on the eastern side of the West Cumberland hæmatite-field, the No. 4 bed, at places, is within a few feet of the surface and immediately underlying the gravel, and, proceeding westward, the ore dips under the Carboniferous Limestone, generally at an angle of from 7 to 12 inches per yard.

The capital required for the sinking of deep shafts varies considerably according to circumstances, and that is why he (Mr. Walker) stated in his paper that "£10,000, £20,000 and even £30,000, do not always cover it now." There is no scale of cost for plant nor for the extraction of the hæmatite nor could there be, because of the different conditions under which the hæmatite is found, nor is there any particular class of engine for either winding or pumping. Some of the winding-engines are ordinary double horizontal and some compound, while some of the pumping-engines are horizontal condensing, some compound and others grasshopper. Much depends on the particular fancy of the lessees or their representatives, although in many cases second-hand winding-engines and pumping-engines, practically as good as new, have been bought for a trifle, as compared with the original cost, and when and where such can be purchased, they generally are bought irrespective of the particular type. Electrical haulage, as well as pumping, is now being introduced at some of the West Cumberland hæmatite-mines.

The amount of water, expected to be met with, varies according to circumstances. The area of the water-shed, rainfall, etc.,

must be considered. If there are neighbouring lessees to the dip, they may, in the natural course of things, drain the water from your mine; or it may be that your mine lies to the dip of your neighbour's, and, if so, it may be that you drain the water from their mine. It may be taken in a general way that the water does not exceed 10,000 to 15,000 gallons per hour, except in cases where the mine-workings are near to or under a river and where the surface has, through mining operations, become damaged, or in case of a river overflowing its banks during extra heavy rains, but this very seldom happens. He (Mr. Walker) had known of mines where over 40,000 gallons per hour had been pumped at one shaft for over a week at a time, but these are exceptional cases, yet, of course, where expected, pumping arrangements must be provided accordingly.

After securing a royalty, bore-holes are put down, and then, if ore is found, a site is fixed for the shaft, and the estimates are made of the cost of sinking, providing of plant, railway connections, etc.

As a rule, lessees do not pay so high a tonnage or royalty rent for hæmatite lying at a great depth as if it were at a shallow depth, and the difference is considered to stand in towards recouping the lessee for his extra expenditure of capital. There is no fixed dead, tonnage or royalty-rent scale in West Cumberland for hæmatite, the royalty is leased on the best obtainable terms and conditions, including a dead-rent, merging into a minimum tonnage or royalty-rent, with a sliding scale, according to the selling price or selling value of the ore, and these terms vary considerably, according to the geographical and geological positions respectively of the royalty.

It was true that the output of hæmatite in West Cumberland had decreased during the past 20 years but new and important ore-fields had recently been found and were being opened in the Egremont district of Cumberland, and it was more than probable that the output of the next 20 years would far exceed the output of years gone by.

There are several instances in West Cumberland where spaces are found in Carboniferous Limestone in hæmatite-mines, which the hæmatite, to use a miner's phrase, has missed; and all these spaces, when cut into, either contain water or show clearly, by their waterworn appearance, that water, at some period, passed

through them. Although he (Mr. Walker) considered that it had no bearing on this question, he might state that he had occasionally, though not frequently, found huge caverns in the hæmatite, with absolutely nothing but hæmatite all round: possibly "heat" may have played an important part in the formation of these caverns.

Hæmatite-mines in West Cumberland have been worked on a considerable scale for over 50 years, at various points, and for a distance of about 8 to 9 miles in length. The length of hæmatite-bearing ground, partly proved and to be proved, at and to the south of Egremont, is about 8 to 9 miles and that to the north of Lamplugh, about 7 miles. There are several areas within the first 8 to 9 miles still entirely unproved, although several explorations are now being carried out, some of which had, so far, been successful. Consequently, the hæmatite-bearing ground in West Cumberland has a possibility of holding out, at a reasonable rate of output, for the next generation, and he (Mr. Walker) might add that practically the same remarks as to unproved iron-ore-bearing ground, as well as to the hæmatite-deposits at deeper levels than those hitherto worked, apply equally to the Furness district of North Lancashire.

He (Mr. Walker) had never visited the mines in the Forest of Dean, but he suggested it was probable that the "solid bars of rock of considerable length" mentioned by Mr. Hoskold, might be faults; and that some spaces, formerly underground water-courses, became filled with hæmatite, while other spaces were missed. There are well defined faults and empty spaces in the Furness district of North Lancashire as well as in West Cumberland. Further he (Mr. Walker) might add that at Brixham, in Devonshire, where iron-ore was formerly worked for several years, there is one very large and well-defined exposed fault; and at Avoca, in Ireland, where a large quantity of iron-ore (containing about 6 per cent. of phosphorus) was worked opencast, well-defined faults can be seen. He understood, when visiting both Brixham and Avoca, several years ago, that mining was not being continued on account of litigation at both places; and he anticipated that, some day, both of these districts will again become important iron-ore mining districts.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE HALL OF THE INSTITUTE, HAMILTON, DECEMBER 10TH, 1903.

MR. JAMES S. DIXON, PAST-PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

THE LATE PRESIDENT, MR. HENRY AITKEN.

The CHAIRMAN (Mr. James S. Dixon) moved, and the members present unanimously resolved, to put on record their sense of the loss that the Mining Institute of Scotland had sustained through the death of the President, Mr. Henry Aitken, on November 21st last.

Mr. Aitken became a member of the Institute in 1879, and all along took an active and sympathetic interest in its affairs. The *Transactions* contain several papers contributed by him. He was appointed a member of Council in 1882, was a Vice-president in 1888 and 1889, and was in the second year of his office as President at the time of his death.

Mr. Aitken came of a good Scotch family; he was one of the sons of Mr. Henry Aitken, a well-known solicitor in Falkirk.

Trained in mining from his youth, and early placed in a responsible position in the management of collieries and ironworks, Mr. Aitken had an extensive knowledge of mining and metallurgy. His enterprising nature led him into many undertakings at home and abroad, and widened his experience. He was manager of the Boghead mines in Linlithgowshire, working the famous Torbanehill mineral, and of the Almond ironworks from 1860 until they stopped working.

He was chairman of the Niddrie and Benhar Coal Company, Limited, chairman of the Lochore and Capeldrae Cannel Coal Company, Limited, and at his death was chairman of the Cadzow Coal Company, Limited and of the Kithill Tin-mining Company, Limited, in Cornwall, and was connected with mines in Spain and many other enterprises. Latterly, he was best known in the district as managing-director of the Cadzow Coal Company, Limited, the duties of which position he carried out with ability and success.

He had an inventive mind, and took out many patents in connection with his profession. He was perhaps the first to recognize the importance of the utilization of the bye-products from blast-furnace gases, and had advocated the adoption of plant for their recovery long before the system was in use in Scotland. His patents for the adoption of these principles entitle him to rank as a practical scientist.

Mr. Aitken may be taken as a type of all that is best in the earlier Scotch mining school. His early training gave him that knowledge of men which is so useful in the management of affairs. He was a hard worker, and endowed with that freshness of mind which made him ever a student, and he was always ready to assist others with information and advice. His upright, kindly and generous nature endeared him to his many friends.

His relations with the members of the Mining Institute of Scotland were cordial and close, and it is with sincere sorrow they lament that, at the comparatively early age of 65, he has passed away from their midst.

The following gentlemen were elected members:—

MEMBERS—

MR. ERNEST COLERIDGE CHURCHWARD, 34, North Bridge Street, Edinburgh.
MR. GEORGE MCDOUGALL, Wellshot Colliery, Cambuslang.
MR. ARTHUR KING, Newton Colliery, Lochgelly.

ASSOCIATE MEMBER -

MR. ROBERT STEEL, 50, Wellington Street, Glasgow.

STUDENT—

MR. WILLIAM JAMES NIMMO DUNNACHIE, Newlands, Mount Vernon.

HENRY AITKEN,

PRESIDENT OF THE MINING INSTITUTE OF SCOTLAND, 1902 AND 1903.

Died on November 21st, 1903.

(*Presented by the Mining Institute of Scotland.*)

DISCUSSION OF MR. H. D. D. BARMAN'S PAPER ON "THE RIEDLER PUMP."*

Mr. H. D. D. BARMAN submitted the following notes of a test made by Mr. John Morison upon the Riedler pump at Dudley colliery.†

The steam-cylinder is 15 inches in diameter, the piston-rod is 2¼ inches in diameter, the stroke is 15 inches, and the differential ram is 4¼ and 6¼ inches in diameter. The steam-pressure at the boilers was 65 pounds per square inch, and there was no vacuum.

At a speed of 146 revolutions per minute, the engine developed 65·75 indicated horsepower; 233 gallons of water per minute were delivered against a head of 720 feet, equivalent to 53·32 pump horsepower. The swept volume of the pump was 242·3 gallons per minute, and the slip was 3·88 per cent. The total consumption of steam was 29·4 pounds, and, exclusive of the water taken from the steam-trap, the net consumption of steam was 26·2 pounds per indicated horsepower.

This test was made after the plant had been running for 12 months, and neither the engine nor the pump had been opened for examination.

The CHAIRMAN (Mr. James S. Dixon) said that the chief feature of the Riedler pump was the fact that it possessed mechanically-controlled valves. Undoubtedly it was one of the best types of forcing pumps used underground, and he was glad to notice that it was doing very good work. Personally, he was not favourable to the adoption of any machinery which necessitated the taking of steam underground.

The discussion was closed, and a vote of thanks was awarded to the author.

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* *Trans. Inst. M.E.*, 1903, vol. xxv., page 238; and vol. xxvi., pages 15 and 55.

† *Ibid.*, 1903, vol. xxv., page 245, and Figs. 5 and 6, Plate X.

DISCUSSION OF MR. J. BALFOUR SNEDDON'S "DESCRIPTION OF THE DUDDINGSTON SHALE-MINES AND THE NIDDRIE CASTLE CRUDE-OIL WORKS."*

Mr. MARK BRAND (Twechar) wrote that, at the present time, the alternating-current system seems to be superseding the continuous-current system in mining operations, particularly where the power has to be conveyed over considerable distances.

The induction-motors, described by Mr. Sneddon, working at 400 volts, are said to start from rest under load, and are employed in driving pumps and haulage-gear. He asked whether the various pumps were fitted with by-pass valves to empty the column when the pump had to be started, after standing, or would the motor start with the full column of water on the pump, before it had got up speed, so as to be in step with the generator? And in the case of the haulage-gears, were they fitted with friction-clutches to enable the load to be gradually taken, or would they start from rest with full load by means of the starting device? He also asked whether any difficulty was experienced through the motors getting out of step with the generator, when working. He further asked whether there was any sparking at the slip-rings fitted upon the motor of 150 horse-power.

In the continuous-current system, with series-wound motors, when the generating plant is started, after being stopped at any time, the various motors will start again under load without an attendant requiring to start them one by one. This is a matter of importance where there are a number of motors, situated at considerable distances from the generator; and he asked whether induction-motors would start again under a load.

The CHAIRMAN (Mr. James S. Dixon) thought that it was worth the consideration of engineers who were introducing electrical plants to decide whether they should not use alternating current in preference to continuous current, especially as the majority of the public-supply companies were adopting the alternating-current system. It certainly was very convenient to have the opportunity afforded, in the case of breakdown, of obtaining a supply from a public company. Of course, with con-

* *Trans. Inst. M.E.*, 1903, vol. xxvi., page 122.

tinuous current in use at a colliery, the difficulty could be overcome by erecting a rotary convertor. The continuous system had done so much good work that colliery-managers were certainly a little perplexed as to the expediency of departing from it; but he believed that, where a new installation was being erected, the alternating-current system was preferable.

Mr. J. Balfour Sneddon said that it was better to select the alternating-current system for a new installation, rather than to instal it at a place where continuous current had been applied. There was no electrical engineer at the Mid-Calder shale-mines, the motors had been running for over a year, and beyond the fact that electrical engineers had tested the motors, after they were in position, the services of an electrical engineer had not been required. The mining fitter had been able to undertake all the work. Occasionally, cables had been spliced, and so forth, but a colliery-fitter could undertake all the work quite easily, especially if he was handy with a solder-bolt.

With reference to Mr. Brand's question as to by-passes, he might explain that it was immaterial whether the motor was started under load or not, owing to the starting-box that was in use. On his (Mr. Sneddon's) initiative, a by-pass was placed on the mining pump at Duddingston shale-mines, as it was working against a static head of over 500 feet. A by-pass had also been applied to the pump at Mid-Calder shale-mines. Personally, he believed that the use of a by-pass was desirable. At the mines no attendants were required, except one at the haulage-motor, which had to be stopped occasionally. This motor, being in the substation, the attendant also attended to the switches for the different motors. At the power-station, an attendant looked after the engine and the different switches there. Generally speaking, the motors had no special attendant, as it was not considered necessary. In the case of the pump, which pumped fresh water from the burn, the motor was started from the power-station, $\frac{3}{4}$ mile distant, where there was a starting-box. There were no clutches in the haulage-gears: they were simply put into the starting position, and then allowed to get up speed.

There was really no sparking, that he had seen, on the motor of 150 horsepower, but at present it was only working up to 80 horsepower.

He did not feel equal to the task of deciding whether the alternating-current or the continuous-current system was the better, but he could say that so far he was perfectly satisfied with the results. There could be no doubt that the alternating-current system was the best for transmitting power to a distance of 2 miles, and it had the advantage of using a high voltage. The results were very satisfactory, and justified the adoption of the arrangement.

At other works, the lowest consumption was about 2½ cwts. of coal per ton of shale burned. In the majority of cases, the consumption of coal was over 3 cwts. per ton of shale burned; but in their case, the entire consumption at Niddrie Castle had been reduced to 1½ cwts. of coal per ton of shale burned.

Mr. Thomas Thomson (Hamilton) said that, assuming that he wanted to start a new work to-morrow, with a haulage similar to what he had seen, he would consider it very unfortunate if he was unable to compare the cost of the electric installation with another type of haulage.

Mr. J. T. Forgie (Bothwell) thought that it was very difficult to arrive at a conclusion such as Mr. Thomson would wish. He thought that the members could reasonably accept Mr. Sneddon's figures. He had given them an idea of the best work done under the old system, and the very best had a consumption of 2½ cwts. of coal per ton of shale distilled in the oilworks; now, at Winchburgh, this consumption had been reduced to 1½ cwts. of coal.

He (Mr. Forgie) asked whether the pumps were started, at any time, without an attendant being present; supposing the pumps should stop by some means or other, and required to be restarted, was anyone sent to perform that operation? So far as he knew, it was an exceptional thing to start a pump without by-passing the water. His contention was that, if the motor was transmitting 60 or 70 per cent. of the power which it was capable of developing, it would hardly be a safe thing to start the motor without sending someone to relieve the load by by-passing the water.

Mr. Sneddon said that, if the motor was fully equal to its ordinary work, there would be no great risk in starting it without by-passing the water. In any case, the shock to the motor itself would not be great, but one had to consider the other

working parts, and perhaps more especially the gearing. In the case of the pump at the shale-mines, working nearly at its full capacity, a by-pass was used, although the makers were prepared to take the risk of any damage occurring in the absence of a by-pass. He did not think that he was, from his electrical knowledge, qualified to state exactly what the effect on the motor would be when starting against the load without using by-passes, but he should imagine that it would not be too good for it.

He (Mr. Sneddon) might answer Mr. Brand's question as to whether the motors get out of step with the generator, by asking whether it was possible for an alternating motor to get out of step. It might lose a step by slip, and be caught up again, just as there could be, say, a slight slip in a belt-drive. It was possible to have two alternators, working in the same circuit, getting out of step, but he was not aware that motors could be said to get "out of step."

There are two generators, and the nature of the work done, for instance, by the retort exhaust-fan, almost necessitates a generator always running, so that the experience of the power being off altogether had seldom occurred. It had happened, however, and the generator was run up from zero, with the motors switched in, and they started all right without having been interfered with. It was only necessary to bring up the voltage quietly. He believed, although his experience on this point was limited to a few instances, that induction-motors, elsewhere, were being started regularly in this manner, and he was unaware of anything to prevent this from being done.

The discussion was adjourned.

DISCUSSION OF MR. ALEXANDER FAULDS' PAPER ON "MINE DAMS."*

Mr. JAMES HAMILTON (Glasgow) said that, in designing a dam, the first consideration is necessarily that of strength to resist the water-pressure, but it will often be found, especially with dams of a small sectional area, that the thickness of dam required to prevent leakage is greater than is necessary to resist the pressure. Thus a comparatively thin dam may as

* *Trans. Inst. M.E.*, 1903, vol. xxvi., page 134.

a whole resist the pressure, but may not prevent leakage. It is always necessary to have a large factor of safety, and the factor of 10 taken by Mr. Faulds is not too high. Mr. Faulds had dealt particularly in his paper with timber dams, but the conditions, under which such dams were suitable, were comparatively rare. They were very difficult to erect, because of the absolute necessity of extreme accuracy in their formation. The stratum in which they are placed must be very hard and homogeneous, because it is necessary to cut and dress the sides with almost mathematical accuracy. These factors, together with the cost, will generally limit timber dams to sites where there is not room for others. Consequently, masonry dams are much more common. In the paper by Prof. Aldis, read before the North of England Institute of Mining and Mechanical Engineers,* the writer mentioned that in the north of England, when a dam was required, the general custom was to make the sides parallel, and to depend upon adhesion to the sides of the mine, in which they were placed, for their support. He (Mr. Hamilton) thought that was the general practice in Scotland as well as in the north of England. He might mention one particular instance, where a dam was placed to resist a head of about 360 feet, equal to a pressure of 156 pounds per square inch. Calculated upon a maximum sectional area of 60 square feet, it was found that a thickness of 19 feet was sufficient to withstand the pressure; and the shearing stress along the four sides of the dam would be about 15½ pounds per square inch. That dam had been quite successful, and it was also practically watertight. Several other dams, calculated upon the same basis, had also been successful. In the dam to which he had referred, the first 3 feet on the water-side were composed of glazed bricks set in a cement-mortar, composed of equal proportions of cement and sand. The remaining 16 feet were built of ordinary hard sound bricks, set in Ardent† lime-mortar, consisting of equal parts of lime and of sand. Water had to be passed through the dam while building, and until the mortar had set, and this was done through a cast-iron pipe 4 inches in diameter. This pipe expanded at the water-end to receive a conical iron plug, turned to fit the pipe and welded to an iron rod passing through the pipe to the outside, by which it was pulled into

* *Trans. N.E. Inst.*, 1883, vol. xxxii., page 201.

† A superior hydraulic lime.

the pipe and screwed tight. An important point in building a dam was to have a thoroughly sound and tight contact between the brickwork and the strata in which it was placed. To get such a connection with the roof was one of the most difficult parts in the construction of a dam, because there was always the risk of a subsidence of the brickwork, after building, leaving a space along the roof. This difficulty could to some extent be overcome by not building too quickly; and when building to have the side of the dam nearest to the water highest, so as to give time for subsidence before closing at the roof. It was necessary, or at least advisable, to grout each layer of brickwork with cement or lime-grout whichever was being used, so as to be quite sure of closing all the openings that might let water through. The placing of a quantity of material inside the dam, such as sawdust, likely to be carried by the water into crevices in the event of leakage, was advisable in order to stop all openings that admitted water. The formula quoted from Prof. Aldis' paper would not allow of the formation of a cylindrical dam to resist a pressure equal to one-twentieth of the crushing strength of the material used. This excluded brickwork, if the pressure approached 80 pounds per square inch; as even firebrick, according to Prof. Rankine, had only an ultimate resistance to crushing of 1,700 pounds per square inch. He had already shown that parallel dams of brickwork had been safely used to withstand a much higher pressure than 80 pounds per square inch, and the greater facility with which such could be built was much in favour of their use.

In conclusion, he (Mr. Hamilton) knew of one case of a concrete dam having been successfully built.

The discussion was adjourned.

GEOLOGICAL PHENOMENA.

The SECRETARY (Mr. James Barrowman) exhibited, by means of the lantern, a series of views of geological phenomena in the British Isles, issued by the Geological Photographs Committee of the British Association for the Advancement of Science, and directed attention to similar phenomena in different parts of Scotland.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, NOVEMBER 10TH, 1903.

MR. H. B. NASH, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. ARTHUR HORT BARNARD, Mining Engineer, Denaby and Cadeby Main Collieries, near Rotherham.

Mr. WILLIAM N. BLAKELY, Mining Engineer, 27, Sholebroke Terrace, Leeds.

Mr. HORACE W. BRADLEY, Colliery Enginewright, Silverwood Colliery, Thrybergh, Rotherham.

Mr. FRANK BENEDICT CRAMER, Technical Manager, International Electrical Engineering Company, 17, De Vere Gardens, Kensington, London, W.

Mr. ROBERT WILFRED CROSSLAND, Mining Engineer, Oldfield Nook, Cleckheaton.

Mr. OWEN HUGHES, Colliery Manager, Rose Hill House, Hindley, Wigan.

Mr. DAVID HUNTER, Mechanical Engineer, 17, St. Ann's Square, Manchester.

Mr. CHARLES OXLEY, Enginewright, Wombwell Main Colliery, near Barnsley.

Mr. JOSEPH RAMSDEN, Colliery Manager, 6, Nowell Place, Harehills Lane, Leeds.

ASSOCIATE—

Mr. FRANCIS WILLIAM GRAY, Surveyor, Birdwell, near Barnsley.

STUDENT—

Mr. REGINALD B. WILSON, Assistant Mining Engineer, Leak Cottage, Church Lane, Chapel Allerton, Leeds.

Mr. F. W. GRAY's paper on "Ankylostomiasis: the Worm-disease in Mines" was read as follows:—

ANKYLOSTOMIASIS: THE WORM-DISEASE IN MINES.

By FRANCIS WILLIAM GRAY.

Few events in the history of mining are more startling and suggestive than the sudden outbreak of the so-called "worm-disease" in the German coal-field, almost paralysing several important collieries and threatening the whole industry of those regions. As the conditions might, under certain circumstances, reproduce themselves in this country, it seems desirable that the question should be introduced to the notice of the members; and the writer therefore begs to submit a few notes based upon the investigations which have been conducted in Germany, in connection with the spread and treatment of this unpleasant disease. The subject has already received the attention of that distinguished physiologist, Dr. J. S. Haldane,* and blue-books have been published dealing with the physiological and medical aspects of the subject;† to these the writer will have occasion to refer. There are, however, other aspects of a technical character with which Dr. Haldane could scarcely deal, but which are of the highest importance to mining engineers.

It is perhaps not admitted directly that the extensive spread of this disease has been due to the conditions brought about in German mines by the extensive system of watering introduced some five years ago by a Government regulation, with the view of minimizing the danger of coal-dust explosions. There is, however, little doubt that to this must be attributed its wide-spread extension. Coal-dust explosions occur from time to time in this country, and as a result the Government are urged to introduce compulsory watering on a system similar to that now in force in Germany; but the Home Office and H.M. inspectors of mines have hitherto wisely preferred to be very cautious in in-

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 643.

† (1) *Report to the Secretary of State for the Home Department on an Outbreak of Ankylostomiasis in a Cornish Mine*, by Dr. J. S. Haldane, 1902 [Cd. 1318]. (2) *Ankylostomiasis: Reports on the Outbreak in the Westphalian Colliery District in Germany*, 1903 [Cd. 1671].

troducing regulations of so far-reaching a character. These, apart from the effect that they are certain to have on the roofs and floors of many mines, with our comparatively horizontal stratification, may bring in their train all the evils from which our neighbours in Germany are at present suffering, and for which they are vainly seeking to find an effective remedy. It is, therefore, very important that the whole of the circumstances in connection with what has occurred in Germany should be present to the minds of mining-engineers in this country, in order that they may be taken into account in case any legislation for more extensive watering in mines, and especially in working-places, were suggested.

The disease has made its appearance at the Dolcoath mine in Cornwall, and in the blue-book issued by the Home Office (November, 1902), Dr. J. S. Haldane gives an explanation of the nature of the worm, from which the following extracts are taken:

The disease now generally known as ankylostomiasis is due to the presence in the upper part of the small intestines of a species of nematode worm. . . . Its definite relation to a disease characterized by anæmia was established in 1854 by Griesinger, who showed that it is the cause of what was then known as "Egyptian chlorosis," a disease very common in Egypt. A few years later ankylostomiasis was identified by Wucherer as one of the commonest maladies in Brazil, and since then it has gradually been found to exist as a very common, widespread and troublesome disease in tropical and sub-tropical countries all over the world. About twenty-five years ago, a disease known at first as "miners' anæmia" attacked the workers constructing the St. Gothard tunnel, causing great trouble and much loss of life. This disease was shown by Perroncito to be ankylostomiasis, which was thus brought into prominence in Europe. It has also appeared among coal-miners at St. Etienne in France, in Westphalia and in Belgium; among brick-makers near Cologne in Germany; and elsewhere. Hitherto its occurrence in England has never been recorded, except by Manson among lascars on vessels from India. . . .

The adult worm lives in the duodenum and upper part of the small intestine, with its head fixed in the mucous membrane. The female is about ½ inch in length, the male being a little shorter. The head is provided with a suctorial apparatus and four curved teeth. . . . The female worm produces an enormous number of ova, which may be easily found in the fæces of all persons suffering from the disease. These ova measure about 0·05 to 0·06 by 0·03 to 0·04 millimetre, are very characteristic, and are easily distinguished by their delicate and perfectly transparent oval shells. . . .

The symptoms of the disease are briefly as follows: The face, and particularly the lips, tongue, and inner surface of the eyelids, become pale, just as in the case of the "anæmia" or "chlorosis" commonly met with in young women. At the same time, the affected person begins to complain of palpitations, and a tendency to dizziness and shortness of breath on exertion.

He and his friends often suspect that he has heart-disease. There is also frequently discomfort or tenderness in the region of the stomach, with capricious or abnormal appetite and other symptoms of gastro-intestinal disturbance. These various symptoms become more and more pronounced, until at last it becomes impossible to work, and a miner would not dare to ascend a ladder on account of the risk of fainting. The pallor and the other main symptoms depend on a deficient percentage of hæmoglobin, the oxygen-carrying constitutent of the blood. The fainting, palpitations, etc., are due to the consequent defective aëration of the tissues, and in particular of the heart, just as occurs in poisoning by carbonic oxide. We have measured the total volume of the blood in several cases, and the results indicate that the "anæmia" is due, not to loss or destruction of blood, as has hitherto always been supposed, but to a great increase in its volume, with a corresponding dilution of the hæmoglobin. The gastro-intestinal symptoms are probably due mainly to irritation caused by the presence of the worms.*

Dr. Haldane's *Report* has been translated into German by Mr. G. A. Meyer, manager of the Shamrock collieries, and has been read with great interest by Westphalian mining engineers.

The "bunches," which appear to be a feature of the disease at Dolcoath, are unknown in Westphalia. Dr. Haldane states that Dr. A. E. Boycott and he are making enquiries with a view to a more detailed report, which will be awaited with interest.

Attention was first called to the existence of this disease in the Westphalian mines about 1890, but it was then not thought to be at all serious. Three years ago, when the disease became so alarmingly prevalent, the whole subject was submitted to the investigation of a number of medical men in the district, some of whom had already been studying the problem. Amongst these, some of the most important opinions have been given by Dr. Tenholt, the Chief Medical Officer of the Miners' General Provident Fund (an institution on similar lines to the West Riding Permanent Relief Fund, but with more extended powers), Dr. Hayo Bruns, director of the Gelsenkirchen Institute of Bacteriology and Hygiene, and Dr. Lœbker, the resident doctor of the Miners' Hospital at Bochum. They have conducted many and various experiments, both in the laboratory and in the mines themselves, extending over a period of six or seven years. On the whole, their conclusions are the same, although, as is to be expected in the study of a comparatively new and little understood disease, they differ on minor technical points. The main outline of their conclusions is shortly as follows:—

* *Loc. cit.*, pages 4 and 5.

Ankylostomiasis is a true infectious disease, and resembles in many respects the cholera-typhus-dysentery group. It belongs, with these, to those diseases in which the alimentary canal is the door of the infection, and which are spread chiefly by the fæces of affected persons. It possesses the characteristic symptoms of that group of diseases which were formerly distinguished as "contagious," that is, diseases which are contracted by direct contact with infected matter. Ankylostomiasis possesses, however, features which are peculiar to itself, and it differs in many essential points not only from bacterial but from all other contagious parasitical diseases. The relation between the conditions of climate in the temperate zone and the conditions which the parasite finds necessary to its development and existence, are such that it is not probable that the disease will ever affect the community at large, at least not in Western Europe. It is essentially a disease peculiar to certain specific callings. It is only where the ova of the worms find conditions adapted to their development that the parasite is likely to multiply. These necessary circumstances are warmth, moisture and darkness. A combination of these three conditions is to be found at many collieries.

As regards the first condition, it has generally been supposed that 73° Fahr. is the lowest temperature at which the parasite can develop. Dr. Bruns states, however, that he has succeeded in hatching the larvæ from the eggs at a temperature varying between 69° and 72° Fahr., but that under these circumstances the development occupied a longer time. The usual period of development is somewhat over 5 days, but at this low temperature 4 or 5 days elapsed before the shell was broken, and 14 days to the completion of the development. Dr. Malvoz, the director of the Liége Institute of Hygiene, has developed ova at a still lower temperature, namely 54° Fahr. Out of 1,000 *Ankylostoma*-eggs he succeeded in hatching the larvæ from 40 at 59° Fahr. In most German collieries, the underground temperature is sufficiently high to fulfil the first condition, and possibly in many British mines also.

Still more important is the second condition necessary to the spread of the disease, namely, dampness. In normally damp excreta, the development of the ova proceeds at the most only very slowly; when it is moderately dry no development takes place;

and when very dry the eggs lose their vitality. So soon, however, as the fæces become diluted by water or thin mud, the ova are speedily hatched and the embryo breaks through the shell as a free larval worm, which after some days furnishes itself with a strong envelope or capsule. At this stage it becomes dangerous to man, and is capable of carrying infection.

A series of experiments has been carried out by Dr. Wortmann, of Baukau, and they prove conclusively the inability of the worms to develop where moisture is lacking. He states that in his observations of the worms hatched from ova in the laboratory, it is noticeable that the moving larvæ never go beyond the confines of the damp excreta. Whenever the head-end of the larva protrudes over this, it is immediately withdrawn into the damp portion again. If the excreta be exposed to the sun's rays until dry, the larvæ will be found stretched out at full length and dead. In order to ascertain exactly the effect of the lack of moisture under actual conditions, a stretch of road was set apart for the purpose in a disused portion of the Julia mine, at Herne. The temperature of the road was constant at 81° Fahr., and it was almost completely dry. The fæces of worm-sick persons were deposited here and observed at intervals, the experiments extending over a period of about 3 months. In every instance, it was found that the excrement was dried up into a hard mass, which, when examined under the microscope yielded no trace of *Ankylostoma*-ova or larvæ, nor did any development take place on the subsequent addition of water. Dr. Wortmann declares as the result of his researches that "the larvæ cannot be developed without moisture, and where the larvæ are partially developed they will die as the moisture evaporates."

The third condition (darkness), is, of course a constant one at every colliery.

On July 12th, 1898, an order was issued from the Royal Department of Mines, at Dortmund, making it compulsory to sprinkle all roads and working places in German mines, with a view to minimizing the danger of coal-dust and fire-damp explosions. This measure has been carried out with the thoroughness characteristic of our German neighbours. It is effected by means of pipes which ramify all over the colliery, and are fitted at intervals with nozzles to which may be attached tubes with

sprays. These distribute the water in the form of a fine mist, thoroughly saturating all around them. In some of the large collieries, incredible as it may seem, hundreds of miles of pipes have been laid. In working-places, where shots are to be fired, the whole neighbourhood is moistened beforehand. Naturally, in the highly inclined seams of Westphalia, the resulting water will drain into the lower parts of the mine. As a matter of fact, an elaborate system of drainage has been attempted in some cases, leading to the sump. This system of sprinkling was got into full operation in the early part of 1900, which synchronizes with a remarkable increase of the disease. The number of cases of ankylostomiasis reported during the last seven years is as follows: —1896, 107 cases; 1897, 113 cases; 1898, 99 cases; 1899, 94 cases; 1900, 275 cases; 1901, 1,030 cases; and to the end of October, 1902, 1,355 cases.

In 1899, Dr. Tenholt, in his yearly report, expressed the hope that they were within measurable distance of the time when the disease would be stamped out, a statement which the figures given above justified him in making. However, in 1900, the number of cases had increased threefold, and, in his report for that year, Dr. Tenholt remarks that the disease had re-appeared in many pits where it had almost been eradicated, a striking phenomenon which needed explanation. The Royal Department of Mines appointed a Commission to enquire into this remarkable revival of the parasite, and especially to consider the question whether "the recent very marked extension of the disease is in any way due to the policy of sprinkling the mine-roads in order to lay the dust, and how, if this be the case, the danger can be met." The Commission do not appear to have arrived at any definite conclusion, but they advised that a strict investigation should be made into the whole matter. Dr. Tenholt stated before this Commission that his observations left no room for doubt that the rapid increase in the number of cases was due to the compulsory sprinkling of the mine-roads. He said:—"This sprinkling favours the spread of the disease in two ways. In the first place, the fæces which may be lying in the roads are diluted and separated; and the ova are given a certain degree of mobility. Secondly, the eggs are washed into the drains, and thence into the sump. Thus, into the sump are gathered the infective germs that have emanated from the workers under-

ground, or at least a portion of them, in particular, typhus and dysentery bacilli."

At one colliery at least, this very undesirable water was used in the workmen's baths, with the not surprising result that an epidemic of typhus followed. Another outbreak was directly attributable to contamination of drinking-water by pit-water. But the chief danger lay in the fact that this sump-water was used for the sprinkling required by the Mine Department; and surely no better means of spreading the contagion could have been devised. Not only does it provide the eggs with the moisture necessary to develop the larval worm, but it also provides the capsuled larvæ with a vehicle by means of which they can reach every part of a mine. The effect of the sprinkling is to cover all the roads with mud. There could not be a better hatching-ground for the ova of the *Ankylostoma* than warm mine-mud. If the eggs fall upon dry ground or coal-dust, they speedily die. If they find suitable environment, the larvæ develop after 2 to 4 days. The larvæ, in their turn, will die if they cannot get moisture, but given warm and damp surroundings they develop a strong skin or shell which is capable of resisting water. The ova and the uncapsuled larvæ if left in water will die, but the larvæ in their water-proof jackets are unaffected. When it is understood that only the capsuled larva is capable of developing mature worms, and that only in the human intestine; and that therefore the disease can only become established by swallowing the capsuled larvæ, not through swallowing eggs or uncapsuled larvæ, it will be readily seen that the use of sump-water for sprinkling purposes is attended with grave dangers. The larvæ having in some way got into the mouth and having been conveyed into the intestines with the food, free themselves from their envelope and develop the adult worms, male and female. These in the natural course produce eggs, which are ejected with the fæces. The eggs are washed into the drainage of the mine, develop the capsuled larvæ, are brought back again and spread about the roads, and in this stage are liable to be absorbed by the workers. Thus the cycle goes on in a rapidly increasing ratio.

Up to the middle of 1902, the campaign against the worm-disease had been carried on chiefly by the officers of the Miners'

General Provident Fund, but apparently with little result, as the disease was increasing in a very alarming manner. Several of the large collieries were very seriously hampered in their operations, and they appeared to think that the measures taken by the Miners' General Provident Fund were not coping with the situation in an adequately efficient manner. Thereupon the Hibernia and Gelsenkirchen companies addressed letters to the executive committee, pointing out the serious state of affairs and urging the adoption of drastic measures. They suggested calling in the aid of some institution especially established for the study of disease-germs and kindred subjects. The executive committee of the Miners' General Provident Fund thereupon appointed a special committee to deal with the whole matter, and, if possible, to find ways and means to extirpate the pest. The committee has been sitting at intervals since that date, and has worked vigorously on the lines indicated. The first sitting was held on September 23rd, 1902, and the following general measures were then advocated:—

1. A stricter oversight into the employment of the underground workers. Persons who are worm-sick shall on no account be employed. Such persons as have been apparently cured must not be allowed to return to work underground, until after the lapse of a sufficient time. A list shall be prepared giving the names of all affected persons and of the colliery where they are employed.

2. The Order of the Royal Department of Mines issued on March 12th, 1900, relative to the provision of underground closets, must be strictly carried out. The ordinary working rules must be supplemented in order to ensure this.

3. Publicity must be given to the nature of the disease, and the danger which it threatens to the mining industry. To effect this, placards must be posted at the collieries, and the officials must verbally instruct the workpeople. Circulars must be distributed among the miners, written in short and simple language that the men can understand.

4. The whole of the workpeople at an infected colliery must undergo a medical investigation—if possible at the colliery itself. Those men who are found to be attacked must be isolated.

5. Sprinkling must be carried out by water other than sump-water.

6. A reward is offered for the discovery of a cheap and practicable germicide, which can be mixed with the sprinkling water in order to kill the eggs and larvæ. The Gelsenkirchen Institute will be asked to assist in this matter.

7. A map shall be prepared showing in colours the infected collieries, and giving particulars of the number of cases reported at each one.

As regards the first recommendation, there had been a considerable difference of opinion as to the method of detecting

those persons who are "worm-sick." Up to the appointment of the committee by the Miners' General Provident Fund, the usual procedure had been for the chief medical officer of that institution to visit the various collieries and inspect the underground workers. Such men as from their paleness and anæmic appearance were suspected of having the disease were picked out, and subjected to a proper examination in hospital. This method of diagnosis was strongly disapproved of by Dr. Bruns. He advocated the microscopical examination of the fæces of every person employed underground at an infected colliery, irrespective of their appearance. Dr. Tenholt divided sufferers from the worms into two classes, "worm-sick" and "worm-affected.' "Worm-sick" persons he defines as "those persons who, in consequence of the presence of the parasites in their intestines, exhibit outward signs of poverty of blood." "Worm-affected" persons he distinguishes from the former class as those "who, in spite of the presence of the parasites, do not exhibit any visible symptoms of the disease: partly on account of their greater powers of resistance; partly, and principally, because of the small number of ova which they have swallowed and the correspondingly small number of adult worms. Such people, if they do not take in any new infection, may remain well for a lifetime, and, unless the worms are expelled by a vermifuge, they will eventually die of themselves." Dr. Bruns takes exception to this distinction, and insists on the importance of removing from the collieries every person in whose fæces eggs are detected, and this he states can only be done with the aid of the microscope. He further states that it is only a question of time and then the "worm-affected" will become the "worm-sick" person, and, in the meantime, he is a source of contagion to all round. A single motion of a worm-sick person may contain many thousands of eggs, without any symptoms of illness being apparent in the sufferer.

When eggs are discovered in the fæces, the affected man is sent into hospital, where a vermifuge is administered to expel the worms. The usual medium in Westphalia is extract of male fern in large doses. The effect of male fern is very severe, and where the patient is much weakened by the worms, may cause collapse. Cases of blindness are also stated to have arisen through its use. Dr. Haldane, in his report, states that where male fern failed to expel any worms the patient was successfully

treated with thymol.* The doctors at Liége prefer male fern to thymol, and administer it in the more palatable form of an emulsion.†

The effect of the parasite upon individuals varies considerably. Dr. Leichtenstern stated that the extent of the anæmia varies as nt/r: that is, the paleness caused by the worms is proportional to the number, n, of the worms in the intestines, to the time, t, during which the worms have lived in the body, and in inverse proportion to the individual resistance, r, to loss of blood. The resistance of the individual is an unknown quantity, and some men can withstand the ravages of the parasite without visible anæmia, while others succumb easily. Nevertheless, these men are each a focus of infection, and this fact has now received official recognition. An order has been issued from the Royal Department of Mines, to become operative from August 1st, 1903, to the following effect:—

1. The owner of every colliery shall, at his own cost and within 2 months of the date of this regulation, cause at least 20 per cent. of the underground workers to be submitted to examination by a doctor nominated by the Government as to the presence of *Ankylostoma*-ova in their fæces.

2. The 20 per cent. are to be drawn as far as possible from the damp and warmer parts of the mine, and are to include representatives of all classes of workmen and not less than 20 per cent. of each class, including the officials.

3. No workman shall be employed until he has been examined, or unless he can produce a certificate to the effect that he has submitted himself for examination within the last fortnight, and that no ova were detected in his fæces. A further examination must be made after the lapse of 6 weeks.

4. The name and address of the doctor shall be posted up on the pit-bank.

5. Failure to comply with this order is punishable by a fine of £15.

The disease is easily amenable to treatment in its earlier stages, but if the worms are not expelled, rapidly assumes a serious aspect. Dr. Tenholt's researches corroborate the statement made by Dr. Haldane, that the ill effects are not due to any decrease in the volume of the blood, but to an alteration in its character. Dr. Tenholt says that the worms secrete a poison, with which they inoculate the body, and all depends on the capacity of resistance possessed by the sufferer. Unless the worms are expelled, the victim becomes generally weakened, with a bloodless appearance,

* *Loc. cit.*, page 5.

† The emulsion is composed of 8 parts of fresh male fern and 2 parts of chloroform with the addition of 110 parts of aniseed and peppermint syrup. In this form it is readily taken by the patients.

and dropsy may set in, which sooner or later ends fatally. After the worms have been present for a certain time, it is not possible to effect a cure, even if they are completely eradicated. The sufferers die through various organic diseases supervening on degeneration of the muscles of the heart. Every case, therefore, of ankylostomiasis must be regarded as serious, and treated accordingly. No cases of the disease have occurred among women or children, excepting in the case of a boy, 12 years old, who had been in the habit of finishing the bread and butter which his father sometimes brought back with him from work, and had in this way contracted the disease. This statement is disputed by Drs. Iberer, sen. and jun., in respect of the condition of the population in the neighbourhood of Anina-Steierdorf, in Hungary, where they declare that the whole population is more or less affected by the worm-disease. Further reference will be made to the statements of these doctors in a later portion of this paper.

With reference to the second paragraph in the recommendations of the committee, an order was issued by the Royal Department of Mines, on March 12th, 1900, compelling the colliery-owners to provide closets in the mines. The order specifies that a sufficient number of closets must be provided for the requirements of the men, the closets must be provided with covers, and so constructed as to be easily transportable: that is, capable of being placed in a tub.

The colliery-owners have shown great promptness in carrying out this order, but it will be readily understood that the task has been both costly and disagreeable. The closets are placed in suitable positions all over the mine, and require to be collected and conveyed to the surface, where the contents are buried, involving a large amount of special labour. Men have to be employed solely for this purpose, and to cleanse and disinfect the receptacles. There is no need to enlarge upon the obvious unpleasantness connected with this work. The official staff of the colliery are made responsible for the proper carrying-out of the order, and any remissness on their part is punished by fines. At the Shamrock colliery, when all the men are down, there is a closet for every 4 persons, and similar arrangements are being introduced at other collieries.

The inspectors of mines have also done everything possible to ensure the carrying-out of the regulation. They appear at the collieries at all hours, without any previous intimation: they descend the shafts unattended by either officials or workmen, and search the mine-roads in every direction for anything contrary to the regulations.

But, although the colliery-owners and the inspectors of mines have done all that is possible, the workmen have not done so. On the contrary, they have resented the order, and when possible, have avoided compliance with it. This particularly applies to foreign and ignorant workmen. In his evidence before the committee, Dr. Tenholt said:—"I believe that scarcely half the workers use the closets, unless they are very strictly watched. I have myself seen recent evacuations left in the water-drain in the immediate neighbourhood (perhaps 10 paces away) of a good and clean closet." In some cases, the closets have even been wilfully damaged. Very drastic measures have been adopted to deal with such deplorable stupidity, and men who are detected are severely dealt with by the law. A very commendable departure has been made by the Gelsenkirchen Company at the Erin colliery, where the disease has a strong hold. They have erected, at a cost of £600, a system of surface-closets. They are constructed on what is known as the "cell" system. Each cell is separated by granite-walls and provided with an effectual flushing-apparatus. They are designed with a view to the utmost cleanliness and freedom from odour, and are under strict supervision. The closets are willingly taken advantage of by the men, to the obvious improvement of the sanitary condition of the mine itself.

Following the recommendation of the committee, a large amount of literature has been distributed among the mining community, including 150,000 circulars giving simple instruction as to the symptoms and danger of the disease. A map has also been prepared, showing the position of the infected mines, and a glance at it gives a graphic idea of what a very great hold the parasite has obtained in the Westphalian coal-field.

The advice of the committee relating to the water to be used for sprinkling has also been generally acted upon, and the use of sump-water has been gradually discontinued, clean water being brought into the pit for that purpose.

The question of the continuance of the sprinkling order was raised in the Prussian Parliament in February, 1903. The Minister of Commerce stated that the regulation had achieved the purpose intended, and that no explosions had occurred since its introduction; he could not therefore hold out any hope of a withdrawal; and he advised that no more water should be used than was necessary to effect the object in view, namely, to damp the dust.

Seeing, therefore, that the sprinkling order was a factor that would always have to be enforced, the committee have been energetically engaged in the search for a material to mix with the sprinkling water, as stated in paragraph 6 of their recommendations. Many and various substances have been proposed, among them chloride of lime, permanganate of potash, sulphate of copper, sulphuric acid and carbolic acid, but no really satisfactory germicide has yet been discovered. Considerable use has been made of a mixture of lime and water (1 part of lime to 4 parts of water) and the roof and sides, the timber, and the ladders in the inclines have been thickly limewashed. The chief objection to the use of lime-water is that it coats up the interior of the pipes and blocks up the sprays: and, after all, its effectiveness as a disinfectant is doubtful. It has been suggested that the mixture should be distributed from an ordinary water-tub, in the same manner that the roads were watered before the introduction of the sprinkling order. But even the use of lime-water (and this is the cheapest of the suggested germicides) is costly, because in order to be really effective it requires frequent and renewed applications. Dr. Tenholt states that a place is only disinfected when it is "covered and permeated with the disinfectant. The mud can only be rendered innocuous by thorough drenching."

It is really not a simple matter to find a substance which will kill the ova and larvæ of the *Ankylostoma* (which in its capsuled stage can survive the action of the digestive juices in the human stomach), and at the same time be admissible under the physical conditions prevailing in coal-mines. Some of the substances proposed could not be used underground, because of their odour and their irritant, corrosive properties; while the cost of others is prohibitive. But a really effective disinfectant must be found, for it has become an urgent necessity.

The committee sent Dr. Lœbker to Brennburg colliery, in Hungary, where the pest has been very successfully fought, in order that he might study the methods used. This colliery is described as being very hot and damp throughout. It has been infected with the disease for over 30 years, the original infection having been brought by Italian workmen after the completion of the St. Gothard tunnel, where, as stated by Dr. Haldane, the disease first came into prominence in Europe. In 1896, 85 per cent. of the men were worm-affected, but, following on the measures adopted, a very gratifying diminution has taken place. In 1898, the percentage of affected men had fallen to 47 per cent.; in 1899, to 26 per cent.; in 1900, to 23 per cent.; in 1901, to 12 per cent., and in 1902 only 8 per cent were reported. In 1897, horse-haulage was discontinued, as it was thought that the horses were infested by the worms. This has since been proved to be a mistake, as the worms only attack human beings. Possibly, however, the abandonment of horse-traction had something to do with the result mentioned, because there is no doubt that the horses stir up and distribute the mud, which is the natural hatching-ground of the parasite. It is also stated that the ova develop rapidly in the dung of horses. In consequence of the heat, the men require a quantity of liquid refreshment, about 7 quarts per man per shift on the average. It is not possible on account of the heat for the men to bring drink with them. Therefore the management have brought cool drinking-water down the shaft from a spring on the surface to certain stations in the mine. Young boys are employed to convey the water to the men in little casks. The water is mixed with lemon-juice, in order to render it more palatable and to diminish the tendency to catarrh of the stomach, which the absorption of so much water creates. Dr. Goldmann, the doctor at Brennburg, is of opinion that 1 per cent. of lemon-juice combined with the gastric juice will kill the capsuled larvæ before they pass out of the stomach, but experiments which have been made at the laboratories of the Liége and Gelsenkirchen Institutes do not corroborate this opinion. The men are also given Indian cane (calamus-root) to chew. The underground workers have, moreover, been examined at regular intervals by means of the microscope, and lime-water has been liberally used. The gratifying result of these measures is not to be attributed to any one of them alone, but to the combination of them all. As

one result of Dr. Lœbker's journey lemon-water is now provided at some of the Westphalian collieries.

An article recently appeared in the *Munich Medical Weekly*, contributed by Drs. Iberer, sen. and jun., the medical officers of the Austro-Hungarian State Railways, based upon their observations in the Anina-Steierdorf district of Hungary. In the course of these observations, they have conducted 26 post-mortem examinations of miners, and also on horses and mine-rats, and have made repeated experiments with mine-mud and pit-water. The authors of this article are of the opinion that the ankylostomiasis found among brick-makers is an entirely different type from that found underground. They say that brick-field ankylostomiasis requires sunlight for its development, while on the other hand the absence of light is one of the conditions necessary to develop the larvæ of the *Ankylostoma* found in mines. But the most important of their conclusions is that this worm is not confined to underground workers, which is the generally adopted opinion in Westphalia. They state that in the low-lying districts of the Danube and Theiss, the worm is apparently endemic among the natives. The worms have been found in persons, who had never worked at a colliery, nor even been outside the confines of their native village, and in men who had been employed all their lives as shepherds on the Alps. The worms do not appear to cause their unconscious hosts any inconvenience, or to affect their health prejudicially. Many of them are well-nourished, in complete possession of their bodily vigour, neither strikingly pale nor unfit for work, and when informed that they were infected by the worms shook their heads incredulously. The authors state that they have examined soldiers just returned from 3 years' military service, and discharged as "medically examined and certified sound" and yet these ex-soldiers were affected. Servians and Bulgarians who had never previously been within 20 miles of a colliery or a brickfield, had *Ankylostoma*-ova in their fæces. The authors express the opinion that heat and moisture alone are not sufficient to cause the disease to assume an epidemic character, and that where it does so unsanitary conditions are present. For this reason they attach little importance to experiments made in the laboratory.

It is possible, however, that the reason why no symptoms of

illness make their appearance in the country-people named by the Drs. Iberer is that the worms are not present in large numbers. Many of the patients treated in Germany have parted with 200 to 300 worms, and the patient treated by Dr. Haldane at Dolcoath mine, was relieved of 260 worms, evidence of the fact that he must have swallowed just so many capsuled larvæ. Wherever, then, the physical conditions are favourable to the development of the ova the disease will assume the epidemic character. Dr. Bruns lays great stress on this point, which he names the "disposition to receive infection." The question, therefore, that chiefly concerns the British mining engineer is whether there are collieries in Great Britian which possess this "disposition."

A reference to the recently-published *First Report of the Royal Commission on Coal Supplies* will afford evidence of many collieries in Great Britain which possess one of the conditions that go to make up the disposition to infection, that is heat. In Mr. H. Bramall's evidence on the deep workings at Pendleton colliery, temperatures are mentioned varying between 64° and 93° Fahr.: and at Agecroft colliery, from 63° to 84° Fahr.: also other evidence was given of high temperatures in the North Staffordshire coal-field.

As the more shallow seams become exhausted, and deeper winnings are made mine-temperatures will increase. So long as moisture is absent, however, heat alone will not favour ankylostomiasis, on the contrary indeed. It is obvious, therefore, that if British mining engineers wish to keep the collieries free from this plague, they must watch very carefully any legislation aiming at introducing sprinkling on the same scale as that adopted in Germany. It is reassuring to notice that the possibility of the introduction of the disease into our collieries is attracting the attention of those in authority. The Sanitary Committee of the Glamorganshire County Council have instructed their Medical Officer to prepare handbills in English and Welsh, for distribution among the miners, explaining the symptoms of the disease. They have also issued a circular to medical men in the county, stating that they have made arrangements for microscopical examinations at the County Laboratory.

A most regrettable feature of the epidemic in Westphalia is the friction which has taken place between the colliery-owners and their workpeople. The workmen state, with very little justification, that the owners are responsible for the present serious state of affairs, and wish to lay upon their shoulders the whole of the onus and financial burden which has been incurred The men also resent any interference with their personal liberty One of the principal causes of the spread of the infection has been the frequency with which the men have changed the place of their employment. They move from colliery to colliery, carrying the worms with them and spreading the infection broadcast, and every attempt to restrain this moving about has been resisted by the men. Another source of disaffection is that every man who seeks work at a colliery must produce a medical certificate of his freedom from worms. This, of course, has to be paid for, and the men say that in addition to their liberty of removal being interfered with, they are put under a financial disability. Further, the sickness caused by the worms has put a severe drain upon the funds of the Miners' General Provident Fund, apart from the expenditure incurred in the measures taken against the disease.

The colliery-owners have expended money lavishly, and may have to spend still more; one colliery-company has disbursed over £12,500 in measures against the disease. Altogether the seriousness of the position cannot be exaggerated, and it behoves all who are in any way interested in the matter to use every effort to prevent its further spread in Great Britain, its introduction being an accomplished fact. If the disease were to obtain a hold in this country, the disagreeable experiences of our German neighbours would repeat themselves to a greater or less extent here.

There is also the contingency that incapacity caused by the worm-disease might be held to constitute a claim under the Workmen's Compensation Act, seeing that the disease was contracted in the course of their employment. This, of course is a moot point, on which the writer would prefer not to express an opinion; but, if it were held that the disease entitled a workman to compensation, it would be a most serious matter, as the following figures will show. If the average wage of all descriptions

of underground workmen be taken at £1 10s. per week, and 10 per cent. of the underground workmen at a colliery numbering in all 1,000 were incapacitated, 100 men would be in the receipt of 15s. per week. This would mean a weekly liability of £75, which on an output of say 7,000 tons would amount to 2½d. per ton. The experience of some German collieries has been that they have had considerably over 20 per cent. of their men laid off, and this, of course, entails a burden of double this amount, besides the loss of tonnage caused by the services of the sick men not being available. Altogether the question is attended with most serious possibilities, and although the writer does not wish unduly to magnify the loss and inconvenience which would result from the spread of the disease in Great Britain, it would undoubtedly be a very serious matter.

The provision of a portable closet for every 10 men, would, in the case of the colliery employing 1,000 underground workmen, entail the purchase of 100 closets, costing, say, £200, at £2 each. Assuming that it required the services of 10 men daily to deal with the removal and emptying of these closets, taking their wages at £1 13s. per week, the working cost would amount to £16 10s. per week. There would also be other expenses in connection with medical examinations, so that the possibility of an increased cost of something approaching 6d. per ton, due to a serious outbreak of this disease, may be regarded as by no means unlikely.

In conclusion, ankylostomiasis is essentially a dirt-disease, and no doubt had its origin in uncleanly habits in tropical countries. Therefore, the obvious preventative is cleanliness, and the improvement of the sanitary conditions underground. Many miners are ignorant, or wilfully unmindful, of the elementary laws of hygiene; and it is at least desirable to lessen the reprehensible and altogether unnecessary habit of leaving infectious matter lying in roads and places where it is likely to be disturbed by the traffic of the mine. This is the first and prime cause of the spread of the disease, and men ought to educate themselves to attend to the needs of nature at home.

It is further desirable that the medical men employed in connection with Miners' Permanent Relief Funds and kindred institutions should be on the watch for suspicious symptoms, especially in foreigners.

It is perhaps a trite saying that prevention is better than cure, but it is a proverb exactly applicable to the danger to be apprehended from this most unwelcome intruder, who, as the Germans have discovered to their sorrow, is more easily admitted than dislodged.

Dr. J. S. HALDANE (Oxford) wrote that Mr. Gray had given a clear and valuable account of the outbreak of ankylostomiasis in the Westphalian collieries. At the request of the Home Secretary he went to Westphalia at the end of September to report on the subject, and from personal observation he could confirm Mr. Gray's statements.

With regard to watering, the evidence was certainly strong that the very thorough German system had greatly favoured the spread of ankylostomiasis. At the same time it must be borne in mind that even without watering, ankylostomiasis might become very serious at collieries. The Belgian colliery-district round Liége appeared, for instance, to be more affected than Westphalia, though there was no watering underground. Intake and main haulage-roads, where systematic watering was perhaps most desirable, had commonly a temperature of under 70° Fahr., so that watering could probably be carried out along them without appreciably increasing the risk of ankylostomiasis. In any case, he thought that the risk of that disease ought not to be allowed to weigh very heavily against any measure which seemed really needed to prevent such serious disasters as colliery-explosions. Ankylostomiasis could be easily treated and cured, and with proper supervision no man ought to be allowed to become even temporarily incapacitated by it; whereas the loss of life from a colliery-explosion was irreparable.

The German system of examining every man employed, and treating in a special hospital every man found to be infected, had certainly proved efficacious, to judge by figures recently supplied to him (Dr. Haldane) through the courtesy of the inspectors of mines in Westphalia. This system had, however, entailed serious expense to colliery-companies, and very substantial loss in wages to the men. As to the latter point, it must be remembered that the very great majority of the men laid up in hospital had not the slightest symptom of illness, although they had a certain number of worms in their intestines.

The one great lesson to be learnt from the outbreaks on the Continent and in Cornwall was that there is urgent necessity for making such regulations and provisions in British mines that pollution of the ground by human fæces shall be effectually prevented. To attain this end careful attention to practical details will certainly be required, but he scarcely thought that the expense need amount to anything at all serious.

If all men who showed any symptoms of the disease were told that they could not be allowed to work underground until they had been treated, no serious cases, and consequently no questions of compensation, could occur. The treatment could be carried out at home, and need not imply any loss of work. He trusted, however, that such effectual sanitary improvements would be carried out in British collieries, in the near future, as to exclude ankylostomiasis effectually.

The PRESIDENT (Mr. H. B. Nash), in proposing a vote of thanks to Mr. Gray, said that the subject, at the present time, was being seriously considered by the Secretary of State, and by others interested in mining, because, as had been well said, prevention was better than cure. Mining engineers ought, therefore, to take any reasonable step towards preventing what might be a source of serious liability in the future, with deeper mines and higher temperatures. Much that had been said of the great spread of the disease in Germany was true, but the members must consider that the German mines "with all due respect to their engineers" were not so well ventilated as those in Great Britain. If they were, he did not think that there would be the same liability to the spread of this disease. Any member who had been in Germany knew that the mines had splendid surface-equipments; but, if more money had been spent in making larger airways and thereby increasing the volume of air passing through them and reducing the high temperatures, the disease would not have become so prevalent as had been the case.

Movable closets, which could be readily cleansed and thoroughly disinfected, placed in suitable recesses near the pit-bottom and passbyes, might be adopted with advantage if the men could only be induced to use them: but unless they were properly attended to, and plenty of strong-smelling disinfectants used, they might soon become a greater nuisance than the present arrangements, defective as they are admitted to be.

The prevention of this disease from obtaining a foothold in British mines depends entirely upon the habits and cleanliness of the men, and therefore a few simple instructions in plain language distributed freely among them, together with the help of their union-officials in explaining the danger of neglecting to carry out these instructions, would in his opinion prove the most efficient safeguard against the general introduction of ankylostomiasis into British mines.

Mr. W. H. PICKERING, in seconding the vote of thanks, said that the question of ventilation had only been mentioned twice, once in Dr. Haldane's report on the Dolcoath outbreak, and again in the Westphalian report. The figures given in the latter report were most suggestive, as only 25,262 cubic feet per minute were provided for 6,000 men, an average of about 40 cubic feet per minute per man—a small quantity. At least four times that amount would be provided in this country, and he thought that they might argue from that fact that the standard of ventilation in Continental mines was low. He should also like to know whether the temperatures were taken with the wet-and-dry bulb thermometer, as he thought it was important that they should know the amount of moisture. He had taken some data of deep mines in Yorkshire, and at one pit 2,240 feet deep, near the pit-bottom, the dry bulb was $69\frac{3}{4}°$ and the wet bulb, 62° Fahr. In the main return airway, the dry bulb was $85\frac{1}{2}°$ and the wet bulb $74\frac{3}{4}°$ Fahr., shewing that in deep mines where they were circulating large quantities of air, the air was exceedingly dry.

He (Mr. Pickering) did not wish to minimize the danger of this disease, but it seemed to him that the goaf was the proper place for the miner to evacuate excreta and to bury them. He also thought that sanitary conveniences might be provided at the pit-bottom and on the main roads. He thought moreover that British discipline was too strong to permit such a disregard of cleanliness as seemed to have taken place in German mines. It was not unusual for a person to be unaffected by a disease, and yet to be capable of conveying the infection to others: this was the case, for instance, with malaria in West Africa, where the negroes were not susceptible, but could communicate it to others. He asked whether such conditions applied to ankylostomiasis.

Mr. H. RHODES said it seemed to be a fact that want of ventilation and consequent greater heat in the mine had a great

deal to do with the spread of this disease. It was notorious that the St. Gothard tunnel, where the disease first appeared in Europe, was badly ventilated, indeed he (Mr. Rhodes) believed that 25 per cent. of the workmen employed on those works were affected by this and other diseases. The quantity of air circulating in the Dolcoath mine, where the disease first appeared in this country, seemed also to have been inadequate. The disease, moreover, was most prevalent in districts where a system of compulsory bathing was in force, possibly owing to the use of plunge-baths; but it was now becoming the practice to provide separate douche-baths for each man. In German mines, there were great difficulties in the way of providing goaf-room, owing to the workings being so steep and to the fact of their being gobbed as soon as they were formed. The men were consequently compelled by necessity to use the main roads, which, being driven in stone, for the most part, were of somewhat restricted area. In Continental mines, the shift is of longer duration, and more food must of necessity be eaten; there is, therefore, great risk of carrying the infection by means of the hand into the mouth.

Dr. J. C. KAYE (West Riding Medical Officer of Health) believed that much could be done, in the way of preventing the introduction of the disease, by the exercise of common-sense in the matter of cleanliness in the mine. He trusted with Dr. Haldane that the mines in Great Britain would be placed in so excellent a sanitary condition that there would be no fear of the disease, and that no special means of prevention would be necessary.

Mr. I. HODGES asked whether the form of ankylostomiasis known as "the brickmaker's disease" was as serious as miners' ankylostomiasis: and what was the difference in effect, as the germs of the one required sunlight, and the germs of the other darkness? It had been generally understood that infected miners were cured by being kept on the surface for a period, but the fact that brickmakers, who always work on the surface, were found suffering from another form of ankylostomiasis made that theory doubtful.

Dr. ALFRED ROBINSON (Medical Officer of Health for the County Borough of Rotherham) wrote that, until recently, ankylo-

stomiasis had in this country been looked upon merely as a curiosity, and the few cases which arrived at British ports were of interest, chiefly on account of their rarity. Now, there was a threatened invasion of the pest, and having recognized that in many parts of the mining districts there are all the necessary conditions for the dissemination of the disease upon its being once introduced, it was everyone's duty to take efficient measures for its prevention. The primary fact to be recognized was that ankylostomiasis was essentially a disease of filth, and was in that respect to be classed with typhoid fever and cholera. It was spread by the contamination of water and mud by the excreta of those who were infected. When these excreta were properly dealt with, the disease must confine itself to the infected host, and would, in time, die out—either by coming to a natural termination, or by causing the death of the affected person.

The preventive measures that should be taken were therefore fairly obvious, and if properly carried out were bound to prove effective:—(1) All persons coming from infected districts should be medically examined before being employed in the mines of another district, and persons found to be infected should on no account be so employed; (2) a proper system of latrines should be provided in mines, and their use should be strictly enforced, so that no contamination of the water or mud in the mines should be possible; and (3) measures should be taken to disseminate information about the disease among the miners, pointing out its dangers and enlisting their interest and intelligent assistance in every possible way.

As had been found in the affected districts of the Continent, it was a matter of the greatest difficulty to eradicate the disease when once firmly established; and therefore its prevention was in the highest degree important. It was satisfactory to know that the matter was receiving the attention of public-health authorities in various parts of the country, and that it was being taken up by such influential bodies as The Institution of Mining Engineers.

Mr. Walter Hargreaves thought that in the report of the proceedings of the Miners Federation it was stated that about 75 per cent. of the miners in Westphalia were affected by ankylostomiasis. Whether Mr. Benjamin Pickard, in making

that statement, meant 75 per cent. of the miners at any particular mine were suffering he did not know, but it was satisfactory to learn from Mr. Gray's paper that such was not the case.

Another feature had been mentioned and that was the spread of ankylostomiasis in German mines by watering the roadways with mine-water, which often contained the larvæ of the worm. He was glad that Dr. Haldane had uttered a warning that they could not afford to neglect the watering of their British mines, and so turn back upon the valuable work done in the direction of coping with the dangers of coal-dust, in order to combat the prospective danger of ankylostomiasis. If it became a choice between coal-dust, with its explosive properties and its bad effect on the human lungs, against ankylostomiasis, they had the authority of Dr. Haldane in giving the second place to the latter danger. They might at the same time take up the question of the sanitary betterment of their mines by providing closets at any or all the places where labour was congested, leaving out, for the present at all events, the workers in and about the faces.

Mr. J. R. R. Wilson agreed with what had been said on the subject of ventilation, for he certainly felt, with regard to the German mines, that if there had been more air, there would have been less heat. He was aware that the problem of ventilating many of these mines was by no means so easy of solution as in the case of the generality of British mines; but some of the total quantities of air were very small compared with the best practice in this country. Three conditions were necessary to this disease—heat, moisture and darkness. Personally, he did not feel very much afraid of the heat in Yorkshire coal-mines: there were some warm mines, but very few were of such a temperature as would assist this disease: and, moreover, where they had the high temperature they had not the moisture, and were not likely to have it.

Mr. J. Gerrard said that, in his opinion, the most important point in that paper, as in all other papers that he had read on the subject was that of dealing with the excrement of the underground workers. It might be true that increasing the amount of ventilation would reduce the temperature: whether it would dry the excrement sufficiently to make it harmless he was not

prepared to say, but he could go into a number of mines where he honestly thought it would not, and in such cases, increased ventilation was not the remedy. When, in April last, he began to make enquiries into the subject, he found it necessary to see personally where the workers around the shaft-bottoms and at junctions on haulage-roads relieved themselves. In discussing the question with colliery-managers he found that many of them were anxious to make provision. The view he took at present was, that as regards the working-faces, there was no need to make provision. In the deeper mines in east Lancashire, many managers had stopped excrement from being deposited indiscriminately in the roadways. At Pendleton colliery, the manager had established square receptacles, made of wrought iron, $\frac{3}{16}$ inch thick, 12 inches square and 12 inches deep, with handles on two sides so that one man could conveniently carry them. A wooden removable top, with a round hole, was placed on the receptacle. At Atherton collieries, a round, iron pail was provided, 12 inches in diameter and 18 inches deep, having a tin lid. These are regularly conveyed to the surface and emptied. The workers have taken to the use of these receptacles, and from a sanitary point of view there is a marked improvement. Probably at Pendleton colliery it may be found possible to substitute for the wooden cover a light enamelled-iron one. It is remarked in the paper that the men may be educated to relieve themselves at home, and so avoid having to do so in the mine. From information received he was doubtful as to this being practicable. At one group of mines, in which 1,039 persons were employed underground in the day-time, only 201 would admit that they regularly relieved themselves at home, 329 admitted that they did so every day in the mine, and 509 were of the opinion that they did so at least once or twice a week in the pit. As to the time, 289 stated that they relieved themselves from 6 to 8 a.m., 444 from 8 a.m. to 12 noon, and 105 from 12 to 4 p.m. At another group of mines, employing 1,229 persons, 412 admitted the home practice, and 817 admitted that they relieved themselves in the pit. Of these 817, 557 deposited excreta at the faces, 128 in the roads, and 132 used the pails provided.

The danger of coal-dust was now well recognized in this country, therefore he would prefer fighting this disease on its

merits, and he would strongly deprecate any diminution of the watering, where required, in connection with coal-dust.

Mr. C. Chetwynd Ellison thought that the best means of dealing with the question would be by trying to gradually improve the habits of the men and boys, which, no doubt, would be a slow process: but with time and by persistently trying to impress upon the rising generation the importance of the subject, if the disease did come there need be very little fear of an epidemic in British collieries. He suggested that sanitary closets should be placed near the pit-top, and also near the pit-bottom and main-roads, and that the special rules should prohibit the committing of a nuisance in any other part of the mine. With regard to compensation, if the cases for which the colliery-companies now had to pay were any guide, he failed to see how they would be exempt from paying compensation where a workman had contracted a disease in the course of his employment. He thought that the system of each man being medically examined, and supplied with a bill of health, would do good in more ways than one, as it would be a great assistance to colliery-managers in the management of their men.

Mr. T. W. H. Mitchell said that all who had spoken had done so from the one point of view of the man. The principle upon which he had acted since the Home Office circular was issued, was to have chloride of lime spread about where the men went. No extra comforts were given, and he thought that was the right way, for in other circumstances the men would wait till the buzzer blew, and then go to where they could relieve themselves. He did believe in removing the excreta, as far as possible; but he thought that the difficulty could be met by the use of chloride of lime, which offered no inducements to waste time. As to closets on the surface, unless kept perfectly clean (and rightly so) the men would not use them; consequently he preferred a thorough system of disinfection.

Mr. F. W. Gray, replying to the discussion, pointed out that the paper was only written with the view of provoking discussion. He was not aware whether capsuled larvæ could live or not without moisture: but the uncapsuled larvæ died without moisture.*

* Dr. J. S. Haldane states that "all observers are agreed that drying kills them at once."

He supposed that dry-bulb thermometers only were used. With regard to the ventilation of the German mines, the Drs. Iberer (to whom he had referred in his paper) stated that, in addition to the high temperature, other unsanitary conditions must be present and continually affecting the workers before the disease would assume an epidemic character; and that the foul air in German mines had much to do with the spread of the disease, because, by lowering the general health of the men, it lessened their capacity of resistance to the worms. With regard to the number of cases, 1,355 were actually treated in hospital in the district of Dortmund. The number of cases actually affected could only be ascertained by a microscopic examination of the fæces of the whole of the workpeople. He had no information as to the percentage of deaths, which did not occur directly from the worm-disease but from the complications which ensued. The weakened state of the sufferer invited other diseases, and he thought that the doctors could hardly state that death was due to the worm itself.

The annual dinner was held in the evening.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,

HELD AT THE HOTEL PORTLAND, CHESTERFIELD, DECEMBER 5TH, 1903.

MR. W. B. M. JACKSON, PRESIDENT, IN THE CHAIR.

The SECRETARY announced the election of the following gentlemen:—

MEMBERS—

COL. CHARLES ALLEN, Wingerworth Hall, Chesterfield.

MR. ROBERT A. BOOTH, Colliery Manager, Worsley Mesnes Colliery, Wigan.

MR. BERNARD LUCAS BRODHURST, The Maolong Lime and Coal Company, Ishamati, Sylhet, India.

MR. WILLIAM DYSON, Assistant to Mining Engineer, Dinnington Main Colliery, near Rotherham.

MR. FREDERICK HENSHAW, Colliery Manager, No. 42 Colliery, Ingagane, Natal, South Africa.

MR. JOHN THOMAS WALTERS, Assistant to Manager and Surveyor, Babbington Coal Company, Nottingham.

MR. HENRY BERTHA WILKSON, Colliery Manager, Francks Colliery, P.O. Box 54, Ermelo, Transvaal.

ASSOCIATES—

MR. WILLIAM C. A. COLLIN, Mining Surveyor, Clifton Colliery, Nottingham.

MR. ANTHONY HUNTER, Under Manager, Clay Cross Collieries, Chesterfield.

MR. FRANK LAWTON, Colliery Enginewright, Wall Street, Ripley, near Derby.

MR. RICHARD WATKINSON, Under Manager, Clay Cross Collieries, Chesterfield.

STUDENTS—

MR. WILLIAM GRIFFITHS ALLOTT, Mining Student, Tibshelf Collieries, near Alfreton.

MR. FRANK S. BARBER, Mining Student, Newstead Colliery, Notts.

MR. CAPELL LISLE AYLETH BRANFILL, Mining Student, Langwith Colliery, near Mansfield.

MR. G. T. CAUSTON, Mining Student, Glapwell Colliery, near Chesterfield.

MR. MATTHEW KITCHIN, Mining Student, Belfort, Harrogate.

MR. GEORGE LANCASTER, Mining Student, Tibshelf Collieries, near Alfreton.

MR. ROBERT PARTRIDGE, Mining Student, Langwith Colliery, near Mansfield.

MR. CONINGSBY W. PHILLIPS, Mining Student, Langwith Colliery, near Mansfield.

The PRESIDENT (Mr. W. B. M. Jackson) said that at the first General Meeting of the members since he had had the honour of being elected President, he desired to make one or two observations. In the first place he begged to thank the members for the honour which they had conferred upon him in appointing him to that office, and to assure them of his intention to further the interests of the Institution during the time he was President. He felt that perhaps his task was rendered more difficult than usual, inasmuch as he was following Mr. Elmsley Coke, who had been such an excellent President for the past two years.

During that period the Institution had made good progress; he was glad to state that the membership had increased, and in addition their financial condition was considerably better than it was two years ago. He believed that Mr. Elmsley Coke would be one of the first to agree with him that, so far as the latter result was concerned, he had been very ably assisted by the Secretary; and it was due very largely to the care and ability of that gentleman, that they were able to congratulate themselves on having such an improvement in their financial condition. He hoped that the progress would be in a like ratio during his term of office.

He hoped to see a large increase in the number of associates, whom it was desirable to see taking part in their proceedings. He ventured to think that associates would derive great benefit from joining the Institution; they could then attend the meetings and take part in the discussions, and, he hoped, read papers. Colliery-managers often experienced great difficulty in selecting the right men for subordinate positions, and the successful and safe working of their pits depended in a great measure upon the character of the under-officials. To his mind, they represented very much the non-commissioned officers of a regiment. The efficiency of a regiment depended upon the non-commissioned officers, and the efficiency of the colliery depended greatly upon the under-officials. He felt that by joining that Institution such associates as were qualifying for positions would gain great advantages and better their positions. Nor were they the only persons who would reap advantages, for he thought that employers and managers would find that they would possess a more efficient staff, inasmuch as these men would gain a wider grasp of their work. He was afraid that it was not

always extremely easy to fill the position of under-manager at a colliery; and he often had to act as intermediary between the manager and the men. Further, if there was any special difficulty to be encountered, the under-officials were always expected to come to the assistance of the manager. He had always found, himself, that the under-manager and the officials were always prepared to give their knowledge and time, and, when necessary, to risk their lives, for the benefit of the pit for which they were responsible.

Referring to the coal-trade, he (Mr. Jackson) expressed the hope that it would improve during the coming year. They had passed through some good times, and at present, some of them were reaping the harvest in a way they did not like. But he hoped that things would improve again by the end of his year of office. Many suggestions had been made as to what was the matter with the trade of the country, and as to what would do them good. Naturally, he was not going to enter into that question, on an occasion such as the present. But he was afraid that they ought to acknowledge that, in some things, they had not kept abreast of their foreign competitors. In the first instance, the training of mining engineers on the Continent was much more thorough, scientifically, than in this country; and very much more theoretical knowledge abroad was expected of them than here. He was glad to say that an Act of Parliament, just passed, would tend, at any rate, towards an improvement in this respect. This Act provided that if a certain time was spent at a university or college, such time should count as part of the period which mining students had to serve so as to enable them to sit at the examination for a first-class certificate. He thought that they had a right to demand that the scientific standard required to obtain a first-class certificate should be higher than it had been. There were better opportunities now than there had been in the past for gaining scientific knowledge. There were excellent universities and colleges in almost every mining district. He did not think that it was unreasonable to expect greater scientific attainments now than in the past. He did not desire to cut down practical knowledge, but he did not think that practical knowledge, coupled with only a small amount of scientific knowledge, was sufficient nowadays.

He had said that they were not quite abreast of the times

in some respects. One thing, however, they knew as employers, that if they had been somewhat behind the times in watching their interests, their men who formed so important a factor in the coal-trade had not been behind in watching theirs. He hoped that working-men were becoming more aware of the fact that, if commerce were to succeed in this country, capital and labour should walk hand in hand. The working-man might think—perhaps he had thought—that he could not extract too much from his employer. But he thought that such an idea might be carried too far. If an employer was unable to get a reasonable return upon his invested capital it was natural that the continuance of his business was less essential to him than if he got a fair return; and, if forced too far, until his business became unprofitable, he might decide to close it. He admitted, however, that colliery-owners could not close their pits when times were bad, and wait for better times to come, as easily as factories could be closed. It was a difficult matter to close a pit, for the costs incidental to the maintenance and the repairs during a period of stoppage were very heavy. But it would be well for working-men to remember that when an employer was working his business without profit, they (the working-men) ran a considerable risk of losing their entire capital, that is, their labour.

Mr. Elmsley Coke said that he could not allow the President's too kind remarks to pass without bearing testimony to the good work of the Secretary. During his (Mr. Coke's) term of office it was his good fortune that Mr. Lewis had become familiar with the work, and the increasing success of the Institution was no doubt largely due to the services of a younger and more energetic Secretary.

Mr. W. Hutton Hepplewhite's paper on "The Beard-Mackie Gas-indicator" was read as follows:—

THE BEARD-MACKIE GAS-INDICATOR.

By W. HUTTON HEPPLEWHITE, H.M. Inspector of Mines.

The Beard-Mackie gas-indicator is intended to be fitted into an ordinary deputy's safety-lamp, and to be used for the detection of the presence of small percentages of gas in the ventilating air-current of the mine, when making an official inspection of the mine, or any district of it. The device consists of an upright standard of brass-wire, bent in the form of an inverted U, and the lower ends are attached to a small ring, forming the base of the support. The base fits over a round wick-tube, and is firmly held in position by the screw-cap closing the oil-vessel. On this ladder-support are arranged six strands of platinum-wires at successive heights, so as to indicate by their incandescence, or red glow, the percentage of gas present in the air. Below the lower platinum-wire, and at about the same distance apart, a thin iron-wire is fixed, and is used as the standard to which the wick-flame should reach, when testing for the presence of gas. When exposed to gas, it is claimed that the platinum-strands will indicate $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$ and 3 per cent. of gas respectively, according to the number of strands aglow. No manipulation is required, but the increasing or decreasing number of strands aglow indicates a corresponding increase or decrease in the amount of gas present.

It is preferable to use a safety-lamp with a long cylindrical glass—the inventors prefer the obsolete Davy—and the back portion must be blackened. When a short glass is used, the ladder-frame reaches into the gauze and the reflections from the rings supporting the gauze and glass may be misleading to the eye, for gas glows on the platinum-wires.

Care should be exercised (especially when travelling in air of varying temperatures) that the wick-flame does not exactly reach the iron strand, and that soot may not accumulate on it; the soot then quickly reaches the platinum-strands, which when once blackened are rendered useless for delicate gas-testing.

When testing for gas, the lamp should be held so that the flame reaches the level of the eye, and the flame should be shaded with some dark object. The lamp must be kept as vertical as possible: if canted, the wick-flame does not spire directly under the iron-wire, and the scale is inoperative.

The principle of the action, on which the detector depends, is the rapid absorption of gas by the platinum-wire. Owing to this property, the platinum becomes incandescent in the gas, considerably above the height of the actual wick-flame, and the bright glowing of the wire cannot fail to attract the attention of any observer.

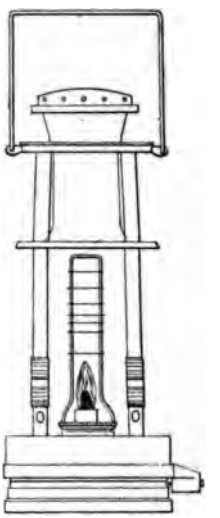

FIG. 1.

The writer has made several experiments with this sight-indicator in a few suitable mines in the Midland mines-inspection district, in conjunction with the Stokes alcohol gas-testing lamp. Consequently he has been able to judge of its merits from the indicated amount of gas present on the alcohol-flame. Without speaking too disparagingly of the scale-indicator for detecting small percentages of gas present in the air, he must say that it failed to show a glow on the 1 per cent. strand when the alcohol-lamp clearly demonstrated that there was this quantity of gas present.

The merits of the device as a gas-indicator begin to assert themselves when the presence of gas in the air exceeds 1 per cent. When the experiments were made at a gate-end lip or waste, where gas was known to be present, it was interesting to watch the gas appear on the strands. The wick-flame was carefully adjusted so as barely to reach the iron strand, then the lamp was slowly raised towards the gas-zone. At the first contact, a glow appeared near the centre of the bottom-strand and then passed to either end. The same occurred with each succeeding strand, until all showed a red glow. If held still at this point, the gas could be observed playing among the strands, yet at the same time no indications of gas were to be seen on the wick-flame.

In mines, where the gaseous condition of the workings is

subject to constant changes due to many causes, the attachment of this device to the ordinary safety-lamps used by officials would be a distinct improvement upon the old method of lowering the wick-flame to the lowest possible point.

Fig. 1 shows the Beard-Mackie device fitted to a Hepplewhite-Gray lamp, with a long cylindrical glass, blackened at the back.

The device has also been fitted to a deputy's safety-lamp, with a glass lengthened to 3½ inches. This lamp has an arrangement which allows the air to feed just over the glass or near to the lamp-top. By using the appliance, the gas is first taken on to the strands, and, consequently, there is a better chance of showing small percentages of gas than with a lamp that feeds lower than the wick-flame.

Mr. Harry Rhodes observed that it was stated in the paper that "the merits of the device as a gas-indicator begin to assert themselves when the presence of gas in the air exceeds 1 per cent." He had always been under the impression that there were other lamps which would detect smaller quantities of gas fairly accurately, and if the Beard-Mackie indicator only "began to assert its merits" when detecting quantities above 1 per cent. he failed to see how it possessed any advantages over existing gas-detectors.

Mr. M. Deacon (Sheepbridge) said that he would like to try that particular lamp, before expressing any opinion upon it. On the general question, however, he said that in certain fiery mines which were well-ventilated, but nevertheless carried into the return-airways a certain percentage of gas, a lamp capable of testing a very small amount of gas was a valuable instrument. It indicated that the mine was giving off gas somewhere or other in more or less considerable quantities, and it had the effect of calling the attention of the manager to the fact, that although he could not find gas when he tried for it in the lips and goaves because of the excellent ventilation—it was absolutely necessary to maintain that ventilation, and unless he did so he would have difficulties. With an ordinary safety-lamp, it was extremely difficult to detect a smaller percentage

of gas, say, than 2 or 2½ per cent. Not very long ago he made a number of careful trials in this respect with one of H.M. inspectors of mines, and he was particularly interested to find that there was difficulty in deciding what was a cap on an ordinary lamp, or whether there was, or was not, any cap at all. Two individuals viewing a very minute cap, or a cap which was scarcely definable, would probably differ according to the object that they had in view. The one wishing to establish the presence of gas might observe the cap, but the other desiring to establish its absence might fail to recognize the presence of a cap. When he was making these tests, he totally disagreed with H.M. inspector of mines that there was a cap on one occasion, but on another occasion when H.M. inspector of mines said that there was no cap he (Mr. Deacon) declared that there was one. He thought that it was very desirable that some delicate means of testing the presence of a small percentage of gas should be adopted by all collieries where gas was present, or likely to be present. If this gas-indicator fulfilled that condition it would prove very useful.

Mr. JAMES ASHWORTH remarked that the Mackie gas-indicator appeared to be designed to assist deputies in America, when making examinations with naked Davy and Stephenson safety-lamps, to estimate percentages of gas by the glowing of a piece of platinum-wire placed at the end of a wire, which was movable vertically or horizontally from the underside of the oil-vessel.* The percentage of gas present was indicated by the height of the platinum-wire over the top of the wick-flame when made to glow by the apex of the gas cap. This invention had been forestalled by his (Mr. Ashworth's) invention† in which platinum-wire was used in precisely the same way as in the Mackie gas-indicator.

The difficulty of applying platinum in this way, or as in the Beard-Mackie lamp was that the wick-flame smoked the platinum, and rendered the test entirely unreliable. The Beard-Mackie gas-indicator was introduced, as something fresh, whereas it was only the ladder-gauge designed by Dr. Clowes to indicate the percentages of gas in the Ashworth-Clowes hydrogen lamp:

* *Colliery Guardian*, 1902, vol. lxxxiii., page 1009.

† British patent, 1897, No. 6,898; and *Colliery Guardian*, 1902, vol. lxxxiii., page 1064.

the only difference being that iron-wires were replaced by platinum. This change, however, did not overcome the sooting difficulty, in fact it appeared to make it worse, as the platinum was immovably fixed directly above the wick-flame. Even this modification was proposed to be added to the Clowes ladder-gauge; but it was considered unnecessary, and it added to the expense of the lamp. It would be seen, therefore, that the Americans had taken the idea from Great Britain, and had simply returned it to us placed inside a different lamp; and then, as soon as it was put into use in this country it reverted back to its application in the original Ashworth-Hepplewhite-Gray lamp. He (Mr. Ashworth), in order to overcome the sooting difficulty, invented an apparatus in which the platinum-wire was placed inside a small gauze at the end of a long circular battery which contained 4 dry cells. When making tests for fire-damp, a current of electricity was passed through a resistance, so as to regulate, before testing, the heat of the platinum. By this arrangement, a deputy could make examinations into the smallest crevices, or into very high places, without the ordinary liability of having his lamp-flame extinguished by an excess of gas. He regretted that he could not show the members the actual apparatus, which was in the hands of the Home Office Committee on the Use of Electricity in Coal-mines. In addition to making tests for gas, the apparatus was arranged for shot-firing; thus, as soon as the shot-firer had made his examination for gas, he could couple his battery to the firing wires and proceed to fire low-tension fuses, and so serve a dual purpose.

Mr. W. H. MASCALL observed that the gas-indicator was constructed so that the platinum-wire was placed immediately over the flame of the lamp, and it was most probable that the wire would become coated with soot at once and therefore the use and effect of using platinum-wire would be destroyed in the detection of gas.

The PRESIDENT expressed the hope that a gas-indicator would not be invented, requiring an electric battery to be carried on the back.

Mr. A. H. STOKES (H.M. Inspector of Mines) said that he would endeavour to reply to some of the points which had been

raised in the discussion. The first standard on the little ladder was made of iron, and not platinum; and it was used to gauge the light. The members had heard from Mr. Ashworth how the Americans took our inventions and how we were the first with a ladder, but ladders were nothing new. They could not detect 1 per cent. of gas by means of an ordinary safety-lamp, and anything which would clearly show so small a quantity would be of value. If there were only 1 per cent. of gas in a large current of air, it showed that a considerable quantity of gas was being given off somewhere in the mine. On the other hand, if by a delicate test it could be ascertained that there was no indication of gas in the return air, a manager could go to bed and sleep comfortably. With regard to the difference of view between Mr. Deacon and one of his colleagues (he thought it right to say that the inspector referred to was not himself) he might remark that some people were colour-blind. [He had known a surveyor, who could not tell a red colour upon a plan.] And it must be admitted that there was a difference between observers of flame: some were able to see a very delicate flame, and others could not see it. Others again could see it if it were deep blue, but not if it were light blue. He suggested the use of a pair of blue spectacles, and they would then see the cap much better than in a white light.

DISCUSSION ON PROF. R. A. S. REDMAYNE'S PAPER ON "THE TRAINING OF A MINING ENGINEER."*

Mr. M. Deacon said that he believed that Prof. Redmayne did—like most professors—advocate two or three years of scientific training prior to practical work. He held a different opinion to the extent that a concurrent admixture of scientific and practical training was the best means of producing a useful man. He thought also that the practical training should predominate in quantity. For that reason he had always adopted the method, with any young men under his care, of permitting them to go to the nearest university, for two days a week and take those subjects which had special application to their practical work, and of letting them on the other four days be engaged in that practical work. He felt confident that that was the best way of producing a useful man for his particular profession.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 243.

Mr. A. H. Stokes (H.M. Inspector of Mines) said that a recent Act of Parliament permitted the Board of Examiners to accept a diploma or degree in mining in lieu of two years spent at the mine, when calculating the five years at the mine which were obligatory by the Coal-mines Regulation Act. What many persons wanted to know, however, was this: Were these young men to go to the university and obtain their degree, or were they to have some pit-work before they went to the university, or were they to take both together? He feared that if the student went first to the university, it would be found that at the end of two years he would be fonder of putting on his university cap and gown than of donning his pit-clothes and coming down to the drudgery of pit-work. With regard to tuition, he asked whether any of the members knew of any college the curriculum of which at the present moment they would like to accept in lieu of two years at a mine. He had mentioned to some of the professors, the plan in operation in Nottinghamshire and described by Mr. Deacon, and asked whether something of the sort could not be adopted. But the reply was "No, we must have the student entirely at our College." They wanted the student all the time of the term, and during the long vacation the young fellow had to loiter about, probably doing nothing, if he were not connected with a colliery. He agreed with Mr. M. Deacon that the student should have both scientific and practical mining together. He should like to see the tuition that the student got from the professor in the class-room taken to the mine and applied there, when his presence was not required at the college, because it was quite possible that the student might return and give the professor a wrinkle.

In that district, there were Nottingham, Sheffield, and Birmingham all readily accessible, and he could not see why a student should not attend one or other of these colleges and spend his spare time down the pit. Was the future manager to be a highly scientific, book-trained colliery manager, or was he to be a practical man and a scientific man as well? Prof. Redmayne made the remark that "in coal-mining, the Americans have and will for many years have, the great advantage over us in that they are possessed of vast stores of coal lying close to the surface; and that their mining engineers are capable of also dealing most effectively with the problems

introduced by deep mining is proved by the fact that they have the deepest metalliferous mines (and deeper than any coal-mine) in the world, which are at the same time among the best and most economically managed mines throughout the globe."* He (Mr. Stokes) failed to see that to know how to manage a deep metalliferous mine was any superior qualification for managing a coal-pit. Further, "On leaving college, the students pass at once into active employment, indeed, during vacation many of them are sometimes so engaged, and are encouraged to do practical work. The writer was assured that no difficulty was experienced in obtaining situations for graduates in subordinate positions as mine-surveyors, mine-bosses, and the like. Prof. Bovey, the Dean of the Faculty of Applied Science at the McGill University said that he had from 20 to 30 more applications for men from the heads of engineering undertakings than he could supply. This year, one of his graduates accepted a post of a value equivalent to £1,000 per annum as a mine-manager without having been, previously, permanently employed at a mine."† He (Mr. Stokes) hoped that all the young men present would as soon as possible obtain a post similar to that, but he declined to express his opinion of the owner who paid such a price for such a mine-manager. He yielded to no man in the interest that he took in the training of the young men of that district and the scientific training of the future mine-manager. He was a great advocate of college-training, but he did hope that they would try to arrange for theory and practice to be combined.

Mr. J. H. W. Laverick (Pye Hill) said that another aspect of the question occurred to him, and it was this: If a young man left school at the age of 16 or 17 and went straight to a mining college, was he more likely or less likely to take to pit-work after that, than if he had started pit-work immediately after leaving school? He was inclined to believe that he would have more *esprit de corps* if he took up practical pit-work immediately on leaving school. There was not the slightest reason why he should not prepare himself in the evenings for a final college-course after three or four years of pit-work. He

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 248.

† *Ibid.*, page 251.

(Mr. Laverick) was one of those who had gone through a course at the Yorkshire College, Leeds, but he had a considerable amount of pit-work first. The college-course only lasted for six months, and his father did not consider that it was enough to fill up his time, so he articled him to a mining engineer in Leeds. Thus, as soon as his college-work was over, he had to rush off to the office or to the pit. In fact, it happened occasionally that before he got to his lectures in the morning he had done a pit-shift. Personally, he was extremely thankful that he had had four years practical pit-work before he went to the college, as this constituted the most essential part of the duties of colliery-management.

The PRESIDENT (Mr. W. B. M. Jackson) said that he was not sure that it was a bad thing to have a little scientific training before they began pit-work. He did not believe in going for three or four years to college, but he thought that work at a colliery was more useful in the case of a man who had had some preliminary theoretical training. He did not want to shorten the practical work, but he did feel that they had not given sufficient attention in the past to the scientific training of students in their branch of the profession. He did not agree with the suggestion that, if a man went first to a college, he was not going to become a pitman afterwards. He had known instances which could be claimed as establishing quite the contrary, though, after all, there was more in the man than in the system of training him. If he meant to get on, he was no worse for the fact that he had a grounding of theoretical knowledge before he came to practical work. He believed that mining students began too young, and that it would be much better if they had a little scientific training before they started practical work in the pits.

Mr. C. P. MARKHAM (Chesterfield) said that some years ago he gave an electric demonstration-set to the Chesterfield Grammar School, and he also provided shafting, a lathe, a slotting-machine, a drilling-machine, benches, etc. He had asked the master of the school to send him some young men, but he had not got one. He issued a notice at his works that any lad who liked to attend the technical classes would be allowed to begin work at 8·30 a.m. and only two lads had taken

advantage of that offer. Men who had grit in them would come to the front, but the present generation preferred clean collars and cuffs and did not like dirty work; and if a man had been to college and rubbed against a lot of swells, he did not like to put on pit-clothes and do work which was not particularly clean.

DISCUSSION OF MR. J. DUNCAN CRIGHTON'S PAPER ON "CENTRAL CONDENSING-PLANTS FOR COLLIERIES."*

Mr. W. PRICE ABELL said that two omissions were noticeable in Mr. Duncan Crighton's paper:—(1) Cylinder-condensation, and (2) he did not state what steam-plants would benefit most by the use of condensers. He certainly mentioned the possible economy as ranging between 25 and 50 per cent., but he did not mention the possible loss in an ill-advised adoption of a condensing plant. At the same time, he (Mr. Abell) thought that it would help members to appreciate this and Mr. Crighton's paper more if the theoretical efficiency were considered.

Recent investigations show that out of an average of 13,500 British thermal units in a pound of ordinary coal, 7,737 units are rejected for the condenser, whilst only 1,273 units are converted into power in the engine-cylinder; or, to put it more intelligibly (that is, by neglecting the loss in the boiler), out of 9,290 units delivered to the engine, only 1,273 units are converted into power in the engine-cylinder leaving 7,737 units rejected for the condenser with an additional loss of 280 units by radiation and leakage. This striking loss, one would imagine, would force its own remedy, but so many qualifications were necessary, and the old adage that "what is one man's food is another man's poison," was very generally applicable to the direction of the forces in nature, and in no case more so than in the utilization of heat.

It was interesting to note the small margin of cylinder-temperature upon which James Watt had to work, and yet his attention to this point of cylinder-condensation made his name immortal. For instance, the engine of his day, working at a pressure of 5 pounds per square inch, had an initial cylinder-

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 77.

temperature of 225° Fahr., cooled down by the condensing water to 65° Fahr., or a range of 160° Fahr. of waste-producing temperature. This variation of cylinder-temperature he reduced to 95° Fahr., by his separate condenser, thus reducing the range of the cylinder-temperature of his day by 65° Fahr. How important this is will be realized when it is remembered that there are plants working where the cylinder-skin temperature varies three times as much as that which James Watt saved; and attention to cylinder-condensation has accounted for more economy than any other part of steam-engineering. Certainly attention to clearances has effected a great deal, but the heat-loosing surfaces is the *bête noire*, and as Mr. Wain stated "condensing should not be the beginning of the economy, but should be the end of it." As an illustration: Prof. W. Ripper about 7 years ago,* went very closely into this matter, and after exhaustive trials in various engines he proved that steam wire-drawn into a cylinder possessed almost the same economy that sharp and early cut-offs had done, thus upsetting another old, accepted but incomplete, theory by practical results. He explained this by the fact that steam at a pressure in the cylinder of 120 pounds per square inch had a temperature of 340° Fahr., and if delivered into the condenser with a vacuum of 25 inches, it had a temperature of 130° Fahr. The difference of temperature in the cylinder at every stroke thus was 210° Fahr., causing a much greater loss through the steam condensing on the wrong side of the piston, than if the cylinder-temperature had been more equal.

He (Mr. Abell) could instance several cases of this kind. It is a recognized fact that compounding of condensing engines under certain conditions does not lead to economy, and there are many engines, where compounding has considerably increased the fuel-consumption.

In conclusion, if a steam-plant is so large that the variation of cylinder-temperature is too great, money can be spent to best effect in improving the engines. If, on the other hand, the cylinder-variation of temperature is small, as is usually found where engines are small for the work, it will be commercially sound to instal a condensing plant.

* "Superheated-steam engine trials," *Minutes of Proceedings of the Institution of Civil Engineers*, 1897, vol. cxxviii., page 60.

Mr. C. P. Markham (Chesterfield) said that at a condensing plant in the north of England to deal with 12,000 or 15,000 horsepower, difficulty was experienced in producing a decent vacuum. At the start, 8 to 10 inches was obtained, but in time by grinding in all the waste-valves and relief-valves, the vacuum was raised to 24 inches.

At Warsop, a condensing plant had been erected to provide fresh water for the boilers, as they used up three or four boilers a year. In three months time, the tubes in connection with the condenser were filled solid with lime, and the whole of these pipes had been taken out. These two cases, so far, had been anything but satisfactory, although no doubt fresh water for the boilers was the great advantage to be derived from the use of a surface-condenser.

Mr. M. Deacon said that he regarded his surface-condenser as a success. He put it down not for the sake of the vacuum alone, but for the sake of pure boiler-water, and it had had this effect in a satisfactory way. The boilers, which were previously heavily scaled, were now in good condition and free from incrustation. They had had a difficulty with their tubes, but it was cured with a weak solution of hydrochloric acid.

Mr. C. P. Markham remarked that the acid would remove all the tin off the tubes.

Mr. M. Deacon replied that it did not do so, unless the acid was applied "neat:" when used in certain dilute proportions it did not affect the tin-lining of the tubes. The question of condensing, after all, was a commercial one, and he had come to the conclusion that where the value of fuel did not exceed 2s. per ton it was -except for the purpose of pure boiler-water—only change for 1s. to condense, but if the fuel cost more than 2s. per ton, then some advantage in the way of economy in fuel-consumption would accrue.

DISCUSSION OF MR. F. G. MEACHEM'S PAPER ON "UNDERGROUND TEMPERATURES."*

Mr. G. S. Bragge (Swadlincote) said that, recently, when taking some temperature-readings, he was surprised to find that in some cases the thermometer when placed in the dust or dirt at the side of the road did not register so high as in the air-current. He could give no explanation, but he found it to be the case on several occasions. He expected that the temperature of the road-side dirt would be higher than that of the air. Mr. F. G. Meachem referred to the influence of the ventilation in reducing the temperature of the workings, and thereby increasing the possibility of working to greater depths than were at present being obtained. The subject was investigated, many years ago, by Mr. E. M. Bainbridge, and the whole question was then carefully worked out. The idea was not new that ventilation would reduce the temperature of the workings.

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* *Trans. Inst. M.E.*, 1903, vol. xxv., page 267.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
HELD AT CREWE, DECEMBER 16TH, 1903.

CREWE WORKS OF THE LONDON AND NORTH-WESTERN RAILWAY COMPANY.

The Crewe works were established in 1843, and are now the largest railway-works in the world. They give employment to 7,500 persons, and more than 700 engine-drivers, firemen, and others at the steamsheds at Crewe station. The company have built 845 workmen's cottages, and they supply the town, as well as the works, with gas and water, the former of which is manufactured at the works, and the latter taken from Whitmore, 12 miles distant. The works occupy an area of 137 acres, and 48 acres of this are covered in. The rapid growth of the works in recent years may be gathered from a comparison of their size 20 years ago. They then occupied 85 acres, of which 27 were covered in by buildings. The number of persons employed was then under 6,000, so that the employees have increased in number by nearly 2,000. At the same time the area of the works has increased by 52 acres, and the acreage covered by buildings has increased by 21 acres, or nearly half.

The Siemens-Martin house contains seven 25 tons and two 35 tons melting furnaces, heated by means of 58 Wilson gas-producers. The steel-making plant is capable of producing 50,000 tons of steel per annum. The rail-mill is driven by a Corliss engine of 1,200 horsepower.

The boiler-shop is 673 feet long by 107½ feet wide, and is fitted with electric cranes, hydraulic rivetting-machines, and pneumatic caulkers. By means of a 15 tons turret-crane, and by hydraulic machinery, complete boiler-shells are rivetted together, doing away entirely with hand-rivetting. When the shell is rivetted together the joints are all caulked by pneumatic tools. The flanging of a boiler-front is completed at one operation, whilst another press is flanging the rear ends in the same way. There are three punching and flanging presses, working at pressures of 2,000 pounds per square inch. A steel

front-end, or fire-box plate, 6½ feet by 4 feet, is flanged in the briefest time imaginable, and the largest press is able to exert a pressure of 650 tons. Since Mr. Webb, the late chief mechanical engineer, introduced steel locomotive-boilers at Crewe, 5,678 boilers have been built up to the end of 1902, and not a single case of rupture has occurred.

The erecting shops are fitted with powerful travelling-cranes, electrically driven, and numerous other machines. Much of the work in the foundry is done by moulding-machines. In the steel-forge the entire process of making wheel-tyres is carried out, from the setting down of the heated ingot under a 1,700 tons Whitworth press, under the gentle persuasion of which it was speedily moulded into the rough wheel-shape. Then a 5 tons becking hammer beat it still further into shape, and the tyre-mill quickly did the rest, and what was at first a solid ingot in a few minutes became a tyre shaped to a nicety. In the steel-foundry are melting furnaces, revolving hydraulic tables for casting wheels, and machines for moulding axle-boxes. Horn-blocks and all locomotive castings are also made. In the galvanizing department is a bath, 19½ feet long by 2½ feet wide, containing 30 tons of liquid zinc, and here all the channelled iron, tank-work, signal-work, etc., is galvanized. In the brass-foundry all the light brasswork for locomotives is cast, and by the separating machine brass and iron shavings were being separated by magnetism.

The total number of locomotive-engines constructed at the works up to March last is 4,315, as many as 146 having been made in one year. The usual time taken to build an engine is about four weeks; but an engine was recently constructed and made ready to work a train in 25½ working hours.

The officials of the London and North-Western Railway Company were thanked for the attention which they had paid to the party in their capacity as guides.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
JANUARY 11TH, 1904.

MR. E. B. WAIN, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS –

Mr. THOMAS PEACOCK, Basford Park, Stoke-upon-Trent.
Mr. R. H. WAINFORD, 29, Glebe Street, Stoke-upon-Trent.
Mr. P. L. WOOD, The Clifton and Kersley Coal Company, Limited, Clifton, near Manchester.
Mr. F. H. WYNNE, 6, Brunswick Street, Newcastle, Staffordshire.

ASSOCIATES—

Mr. J. E. MOULD, 285, Leek Road, Hanley.
Mr. RALPH SHAW, Florence Colliery, Longton.

STUDENT –

Mr. W. J. HALLIMOND, 32 ', Second Avenue, New York, U.S.A.

OLD SHAFTS AT HANLEY.

Mr. J. C. CADMAN wrote that he wished to draw the attention of the members to the collapse of the old shaft at Hanley, and to express sympathy with the relatives of the unfortunate man who thereby lost his life. His object in doing so was to point out to the authorities in the district the necessity of obtaining full information and particulars of the sites of old disused shafts, and of seeing that they were, if of no further use, filled up at once and before any building could take place at or near the

site. He thought that local authorities had the power to see that this was done for the safety of the public; and, further, he believed that all owners of lands on which such shafts existed would most willingly fill them up or allow the authorities to do so. Considering the geological condition of the coal-field, and the fact that the various seams of coal crop out under some of the extended areas of towns, coal had been worked in bygone years by shafts from 100 to 150 feet deep, similar to the one at Hanley and would be quite as dangerous if they have not been filled up. He would strongly advise authorities, whose position was in all probability the same as that of Hanley, to obtain information as to the site of old disused shafts in the district, to have them correctly marked on a map of their district, and if possible to ascertain whether they were filled up or not. He felt sure that every member of the Institute would willingly give the authorities all the information in his possession, so as to make such map a complete record; and thereafter steps could be taken to prevent a recurrence of the Hanley disaster.

Mr. W. N. Atkinson said that it was desirable that the position of old shafts should be ascertained, and that they should be filled up. The members of the Institute might assist by looking up any plans in their possession, which showed old shafts round about the populated parts of the district. It was possible that there were other old shafts built over, or covered in, in the same way as the one in John Street was.

Mr. F. H. Wynne's paper on "Native Methods of Smelting and Manufacturing Iron in Jabalpur, Central Provinces, India," was read as follows:—

NATIVE METHODS OF SMELTING AND MANUFACTURING IRON IN JABALPUR, CENTRAL PROVINCES, INDIA.

By F. H. WYNNE, B.Sc.

Introduction.—It has been the writer's good fortune, during a short professional visit to the neighbourhood of Jabalpur, Central Provinces, India, to have the opportunity of observing, and collecting a few notes upon, the actual process of the reduction of iron from its ores as practised by the natives of that country.

To anyone acquainted with the magnitude of the works, the massiveness of the machinery, and the colossal erections, usually associated with the extraction of iron from its ores in Europe and America, a short description of a primitive method which has prevailed throughout centuries, with little or no attempt at improvement, will (it is hoped) prove of interest: perhaps not so much from a practical, as from a scientific and historical, point of view.

The object of the author is not, in fact, to provide new ideas for the consideration of the members, but rather to place on record in the *Transactions* a notice of an industry which, although declining, will for reasons stated further on, probably survive on a small scale through many generations.

General Review of the Industry.—It is practically impossible to fix upon any date for the commencement of the manufacture of iron in India; but that it had reached a high pitch of excellence many centuries ago is proved by the presence of the renowned memorial-pillar at Delhi. This is a shaft of wrought-iron, 50 feet long and 16 inches in diameter, bearing an inscription recording that it was erected in the year 319 A.D. There is little doubt that the art had been in existence very many years previous to that period.

Reasons for the decline of the industry are, however, not far to seek. In the first place comes the importation of European iron, which is considerably cheaper than the native product and, being in the form of bars, rods, etc., is in a better condition for working up. This, together with the facility for obtaining scrap-iron from the large railway and other works, has caused imported metal to replace the native material in many directions. Secondly, we have the peculiar temperament of the workers themselves, which does not, it must be said, tend to the improvement either of appliances or of conditions of labour.

The actual smelters, or *bhatti-wallas* as they are called, are invariably poor low-caste individuals, belonging for the most part, to the more ancient and aboriginal tribes. Their chief characteristic is a lack of initiative and a want of ambition to improve the conditions of their own existence. Their only object is, apparently, to earn just sufficient to satisfy their immediate wants. It is not difficult to see that an industry in the hands of such men as these has little prospect of advancement, or of any material improvement either in organization or methods of working. A further obstacle in the way of improvement is the fact that these smelters are employed by a small capitalist or middleman, who is generally also *malgazar* or landlord of the property on which the furnace stands, and whence the necessary fuel is obtained, and whose only interest in the work is the amount of money to be made on the iron manufactured.

The *lohars* or blacksmiths, who work up the iron prepared by the smelters, are a much more intelligent class of men. They prefer independence, so that, when not engaged in carrying out orders, they may mend tools and pick up other odd jobs. They can turn out articles of really good workmanship, requiring considerable skill. They have been known to make rifle-barrels, wonderfully true and symmetrical, and shaped octagonally inside to give, it is supposed, a spin to the bullet similar to straight rifling. The *lohars*, for the most part, know little or nothing of the actual smelting process and of the construction of the furnace, and only those who are not clever enough to earn a livelihood as smiths become *bhatti-wallas*.

Except in isolated spots in the immediate neighbourhood of iron-mines and furnaces, very few *lohars* confine themselves

to the use of native metal only. The majority remove their shops to the larger towns, and turn their attention to the manufacture of articles from the cheaper European iron.

At its present price there is a very limited demand for the Indian iron, but such as it is, it appears to be fairly constant. Consequently, although there is so little prospect of any further development of the industry on the present lines, it is equally certain that it will not die out entirely for many years. The principal reason for the demand for the native metal arises from its great malleability: for certain articles in universal use can only be made from this iron with the rude appliances at the disposal of the common smiths. Two instances may be quoted, the *kulhari* or *tangi*, a small axe in general use, has a hole made in it, in which to fix the wooden handle, by hammering it out while hot with a large nail used as a sort of mandril. The *karrahi*, a kind of shallow frying-pan with two handles, is formed by hammering out the cold iron after it has been roughly shaped at a red heat, a process which also has the effect of giving the metal a fine polish.

FIG. 1.—GENERAL VIEW OF FURNACES.

Local prejudice in favour of home-made iron is very strong, and it is only on account of its high price that, where possible, it is replaced by imported material. It is supposed to be more durable and to corrode less than the latter, and on account of its malleability a tool made from it is easier to mend when broken.

Construction of Furnace.—Before proceeding with a detailed description of the furnaces in use in Jabalpur it is as well to recall that Dr. Percy, in his book on the *Metallurgy of Iron and Steel*, made a division of the furnaces of India into three distinct types:—

(1) The simple conical furnace, with two openings at the bottom, one for the tuyeres, and the other for the removal of the slag and iron. These furnaces (Fig. 2) are very small, and a bloom weighs only 5 or 6 pounds.

FIG. 2.—CONICAL FURNACE (FROM A PHOTOGRAPH PRESENTED BY DR. W. SAISE).

(2) The bank-furnace, consisting of a cylindrical cavity, 15 inches to 18 inches in diameter and 2½ feet deep, in a bank of well-tempered clay. On either side of the bank, and at its foot, is a hole, one for the tuyeres and the other for the removal of slag. The bloom is withdrawn by means of tongs, through the mouth of the furnace. Six lumps of iron, each weighing 20 pounds, can be worked off in a day, since no part of the furnace is destroyed in withdrawing the bloom.

(3) A vertical trench, 1½ feet square, and the same size from top to bottom, is made in the side of a mound; its entire

height is from 8 feet to 10 feet outside and from 6 feet to 8 feet inside, the hearth being about 2 feet above the ground-level. The bloom is extracted in a manner similar to that adopted in the furnace at Jabalpur, and the blooms vary in weight from 150 to 200 pounds.

Although the Jabalpur furnace does not belong to any of these types, it may be regarded as a modification of the third one. Its principle of construction is the same, but it differs considerably in certain details. The furnaces are built in this district, as doubtless they are in all other parts of India and Burmah, from memory entirely. In the neighbourhood of every well-known mine, where smelting has at any time been carried on to any great extent, there are two or three families who know how to make a furnace and understand the process of smelting. This knowledge is inherited from their forefathers, and they in turn will transmit it to their descendants. The primitive methods of construction and simple appliances now used by the natives are probably the same, almost to the minutest detail, as those that have been employed from time immemorial.

FIG. 3.—FRONT VIEW OF FURNACE, SHEWING TRENCH.

The furnace is built solely of clay and sun-dried bricks or, rather, plates and blocks, and is partly aboveground and partly belowground. From behind, it appears as a semi-circular erection rising from 2 feet to 3 feet above the level of the ground.

In front, a trench, A, is dug, 3 feet deep, 3½ feet wide bottom, 4 feet wide at the top, and from 10 to 12 fee (Fig. 3, and Figs. 8, 9 and 10, Plate VI.).

The hearth, B, of the furnace, which slopes towards th at an angle of 15 degrees, is raised from 10 inches to 12 above the bottom of the trench (Figs. 8 and 10, Plate VI.). is a height of about 5 feet from the front of the hearth mouth, C, of the furnace. The mouth is an opening 10 inches square, and over it is placed a flat cover, inches thick, l open a space, inches squar charging the f with ore an (Fig. 10, Plate

Fig. 4. Tuyeres.

The walls, each side of the are 1½ feet and, from fr back, the dista the top of the f is 2 feet 9 The rounded-c ners give the f its semi-circula as shewn in (Plate VI.).

The front v is only 1½ to 2 thick, and it down from th sloping slightl ward, to within 1 foot of the front of the hearth, B, (Fig. 10, Plate VI.) wall has to bear most of the weight of the burden, and a only supported part of the time, by its adhesion to the walls, it must be kept thin; on this account, that is, its ur able weakness, and the strain to which it is subjected, it is necessary to replace it with a new one about once in 8 d

The remainder of the front of the furnace between th wall and the hearth is completed by a curved slab of drie

H, called the *gaderi*, which is placed in position along the front of the hearth together with the tuyeres, I, I, and their supports (Figs. 8 and 10, Plate VI.). This slab, nearly 2 feet long, 6 inches wide and 2 inches thick, is pierced with 20 holes, $\frac{3}{4}$ inch in diameter, almost but not quite entirely through the slab; it also has two dents, by means of which it is held in its place by sticks resting on the bottom of the trench.

The tuyeres, I (Fig. 4), made of clay and sun-dried, are of the following dimensions:—1 foot 9 inches to 2 feet long, 4 inches in diameter outside at one end, and tapering to 2 inches at the other. The inside aperture tapers similarly with the outside from 2 inches to about 1 inch. The tuyeres are placed in position against the bottom edge of the front wall, and are kept there by two clay-supports, J, standing on the top edge of the *gaderi* (Fig. 10, Plate VI.). These supports, 2 inches thick, are 6 inches long, 2 inches wide at the bottom, and 6 inches wide at the top, where they are shaped so as to ensure a firm hold on the tuyeres (Fig. 8, Plate VI.); and the latter are directed sloping downward, to converge at the angle at the back of the furnace where the back wall and the hearth meet (Fig. 10, Plate VI.).

The whole of the front of the furnace, from the top of the *gaderi* to the bottom of the front wall, is then closed with a plastering of damp clay, and the furnace is ready for work to commence.

The complete furnace takes from 10 to 20 days or more to construct. It is built in sections of about 1 foot each, and, after the addition of one of these, it is left three or four days to dry thoroughly before another section may be added. A *bhatti-walla* and his family will give 3 or 4 hours every third or fourth day to construction, the rest of their time being taken up in their ordinary pursuits of agriculture; but they do not get any pay until the furnace is completed and in actual operation.

Blowing Apparatus.—The blast is obtained by hand-labour from a pair of cylindrical bellows (Fig. 5) made of goat-skin, K. They are 10 inches in diameter and 18 inches long when at full stretch. The air-outlet is at the bottom, through bamboo-pipes, which are joined to the projecting ends of the tuyeres, I, by a wooden nozzle or sleeve-joint, N, with two holes, one for each tuyere (Figs. 8 and 10, Plate VI.).

The inlet-valve is placed on the top end of the bellows, and is constructed in a rather ingenious manner. The flat top is slit across, and the skin is prolonged to form two flaps: one of these is stitched to a straight strip of split bamboo, and the other flap folds over it. In depressing the bellows, the operator grasps the two flaps between his finger and thumb, making the inlet air-tight; on raising them he slackens his hold, and the flaps fall away for the air to enter. To enable him to do this, there is a leathern loop-attachment, similar to that on the ends of an ordinary concertina.

FIG. 5.—BLOWING APPARATUS.

The bellows-spout formsa tight joint with the double wooden nozzle or sleeve, which is kept firmly in position, by a wooden stay, pressure being put on this by a bow of bamboo fixed under two wooden pegs in the side-walls of the furnace (Fig. 5).

The bellowsman grasps one bellows in either hand, and raises and depresses each alternately, so that a fairly continuous blast is obtained. He sits upon a stool placed on a platform, L, fixed across the trench in front of the furnace (Figs. 8 and 10, Plate VI.). A screen, M, of thin clay-plates is placed above the top of the furnace on three sides, to prevent the smoke and ashes from blowing in his face. The furnace-front faces the north, and further protection from the sun is obtained by erecting a roof of wattles and leaves supported on four rough poles, forked at the top so as to carry crossbars (Figs. 1 and 7).

Ores and Fuel.—The ores used are of two descriptions, both, however, being red hæmatites:—

(*a*) Micaceous hæmatite.—This is a finely-laminated ore. It is specular in fine fragments, and gives a distinct blood-red streak.

It occurs in low hills which rise out of the surrounding plain of alluvium to a height varying between 50 and 150 feet, and is worked in irregular galleries, either directly on the outcrop or in the sides of large quarry-like excavations, or from small shafts sunk vertically from the surface (Fig. 6).

FIG. 6.—RAISING IRON-ORE FROM A SHAFT.

The ore is found in thin beds, rarely exceeding 1 inch in thickness, and each bed is so finely laminated, and the ore is so soft, that it crumbles in the fingers into thin flakes. It is intimately interbanded with thin compact argillaceous layers, and these layers extend in paper-like sheets into the bands of ore itself. The strata are at one and the same time so soft, so tough, and so intermixed with the above compact argillaceous layers that the working of them is an easy process, with little danger from falls of roof or sides.

In some localities, the argillaceous layers give place to hard bands of jaspery quartz. Such spots are, however, left severely alone, both on account of the additional work required in getting the ore, and the difficulty of separating it from the hard bands when got.

An average sample of this ore gave the following results on analysis:—

Iron, Fe...	60·700
Silica, SiO_2	7·450
Sulphur, S	0·019
Phosphorus, P	0·075
Water, H_2O	0·250

(*b*) Red ochreous hæmatite. This ore is a semi-ochreous hæmatite. Specular ore occurs in irregular concretions within the ochreous variety. The ore is interbedded with quartzose layers, which in some localities largely predominate over the ferruginous part of the rock.

This mineral is worked in a manner similar to the micaceous ore.

An analysis of the ore gave the following result:—

Iron, Fe...	65·500
Silica, SiO_2	3·370
Sulphur, S	0·082
Phosphorus, P	0·110
Water, H_2O	0·330

This ore is also extensively employed in the preparation of red paint.

The only fuel used is charcoal. It is the most costly item in making the crude iron, and is prepared from wood grown in the neighbourhood of the furnace on land belonging in some cases, to the *malgazar* or landlord, previously referred to.

There is no flux of any kind introduced, beyond what the ore itself contains. Experiments have been made by the Government to test the effect of a flux, but the yield of iron was not so high as by the old method.

Method of Working.—When the *gaderi* has been fixed in position at the front of the hearth, the bottom of the furnace is filled to the level of the *gaderi*, with a mixture of cow-dung and charcoal (Fig. 10, Plate VI.). The front and tuyeres are then plastered with clay, and the whole body of the furnace is filled from the charge-hole with charcoal, the quantity required for this purpose being about 84 pounds. This is ignited by blowing in through the tuyeres a few fragments of glowing embers, and the whole is speedily in blast.

The furnace having become thoroughly heated, and the charcoal having sunk sufficiently for the purpose, a basketful of ore (9 inches in diameter, and 6 inches deep), carrying 14 to 18 pounds, is introduced; and a further supply of a basket-

ful of charcoal (16 inches in diameter and 11 inches deep), weighing about 14 pounds, is added (Fig. 7). At regular intervals, of from 30 to 40 minutes, this addition is repeated until, in all, 20 basketfuls of each material have been added. At similar intervals also a hole in the *gaderi* is poked clear by means of an iron-rod, and the slag allowed to run out. The bottom row of holes is used first, and the top row towards the end of the operation. It will be observed that the number of holes in the *gaderi* corresponds with the number of basketfuls of ore and fuel added for one bloom (Fig. 8, Plate VI.). A new *gaderi* is, of course, required for every bloom, and the tuyeres and supports have to be renewed at the same time.

Fig. 7. - Back View of Furnace, shewing Charging.

At the end of 10 or 12 hours, the bloom is ready for extraction, and the tuyeres have been burnt away to within an inch or two of the front wall.

The bellows and the stage are removed from the trench. The sprags are knocked out from the *gaderi*, and this, with the rest of the furnace to the bottom of the front wall, is broken away and the bloom rolls out into the trench. Two men take hold of it with a long pair of tongs, and drag it out of the trench on to the ground, and it is cut while still hot and soft, into two parts by repeated blows with a heavy hatchet. The bloom when cooled is in appearance a large spongy mass, so full is it of holes and vesicles, and adhering particles of slag.

The weight of a bloom, in its unrefined condition, is about 70 pounds; and for this about 350 pounds of ore are used, and

360 to 370 pounds of charcoal consumed. From these figures it will be seen that only 20 to 25 per cent. of bloom is obtained from the ore, the remainder being lost in the slag, a sample of which has been found to contain 41 per cent. of iron.

Refining and Preparing for Sale.—The rough bloom is heated to bright redness, in an ordinary blacksmith's forge, with charcoal, and then hammered out on an anvil to remove the slag and impurities; it is afterwards cut into pieces and formed into round cakes about 6 inches in diameter and 1½ to 2 inches thick, in which state it is usually sold to the *lohars*. The writer one day encountered a man who had journeyed on foot a distance of 60 miles to purchase iron and was returning, in the same manner, laden with a year's supply of metal. This consisted of about 60 pounds of pats or cakes, as described above, for which he had paid the sum of 2 rupees, or 2s. 8d. in British money.

Blacksmiths, who live and work in the neighbourhood of furnaces, will, however, purchase the rough blooms, and after first heating and hammering out the slag, work the metal direct into the article required. The chisel and *tangi* exhibited at the reading of this paper were thus made.

The following is a list of articles commonly manufactured from native iron:—Pickaxes, sickles, axes, ploughshares, *kodalis* or picks (with one point only), *phowras* (a kind of large hoe), and *karrahis* or shallow pans with two handles.

Costs and Distribution of Labour.—The following figures, taken from the reports on the iron-industry of India, published by the Indian Government, in the Agricultural Ledgers, No. 17-1898 and No. 14-1900, show the approximate cost of labour, fuel and ore, and the distribution of labour in the different departments of charcoal-burning, smelting and refining.

Each furnace, when in work, employs on an average the following number of persons, at the appended daily wage:—

	Persons.	Per Head. Rup. An. Pies.	Total. Rup. An. Pies.
Cutting wood and making charcoal	8	0 1 3	0 10 0
Getting and carrying ore to furnace	2	0 1 2	0 2 4
Managing furnace, 1 skilled man ...	1	0 3 10	0 3 10
Do. 1 labourer ...	1	0 2 0	0 2 0
Totals ...	12		1 2 2

The output for this expenditure is one bloom of crude iron, weighing about 70 pounds, which on refining yields from 35 to 40 pounds of merchantable iron, or a production of not more than 10 to 12 per cent. from an ore containing at least 50 per cent. of metal.

For each furnace, a yearly royalty of 12 rupees is also payable to the Government for the ore used, and 38 rupees for the wood consumed, if from the State forests. This amount, spread over the working period of 7 months (since no work is possible during the rains, which are prevalent from June to October inclusive), makes an additional charge of 4 annas per day, so that the total cost of the bloom is 1 rupee 6 annas 2 pies and it is sold on an average for 1 rupee 8 annas, at a profit of 1 anna 10 pies or about 8 per cent. Such a profit would not, however, be earned in actual practice, for the estimate of 4 annas royalty does not take into account those days on which the furnace is not at work, and on which days wages, paid monthly, would still be accruing.

The output of the Jabalpur district in 1898 was about 100 tons of blooms, and from 200 to 300 persons were employed.

The refining process is carried out, as stated above, by a different set of workers. There are eight employed, in all, at one refinery. One blacksmith (*lohar*), who holds the iron and directs operations, is paid at the rate of 6 annas per day, and five hammermen and two bellowsmen are paid at the rate of 2 annas per day, a total of 1 rupee 4 annas per day. They work from 5 a.m. to 1 p.m. and will refine in this period three blooms, or about 210 pounds of crude iron, giving a produce of 120 to 140 pounds of refined material (somewhat on a par with British puddle-bar) according to circumstances.

The refined iron is sold, as already stated, to the blacksmiths in round cakes, at the rate of 3 rupees (4 shillings) per maund (80 pounds).

European iron costs about 4 rupees (5s. 4d.) per maund (80 pounds) for bars, strips, etc.; and scrap-iron costs from 8 annas to 1 rupee 12 annas (8d. to 2s. 4d.) per maund (80 pounds).

The blacksmiths who work up the iron do so under the following arrangement. The person who desires certain articles, buys sufficient iron for the purpose, and hands it to the smith who charges for his work at the rate of 4 rupees (5s. 4d) per maund (80 pounds) weight of finished articles.

It is probable that discrepancies will be noticed among these figures relating to costs and distribution of labour, but unfortunately such discrepancies are unavoidable, on account of the difficulty in obtaining anything like true and accurate data to work upon.

Steel.—Although steel is manufactured in some districts of India, both by the carburization of wrought-iron and also by the decarburization of cast-iron, this industry has no followers in Jabalpur, but is confined to the more southern districts, namely, Madras and Mysore.

There is, however, a direct product from the furnace under consideration that possesses steely properties to a considerable extent. It is called by the natives *kheri*. It is manufactured in precisely the same way as the ordinary iron, and its character is supposed to be due to the ore from which it is derived. The metal obtained is white, glittering, and very hard: it is brittle, and is used chiefly for steeling the edges of axes and chisels, and facing other tools. It is more expensive than ordinary iron, and the selling price sometimes is as much as 3½ or 4 rupees (4s. 8d. to 5s. 4d.) per maund.

The ore from which *kheri* is produced is a manganiferous, micaceous hæmatite interbanded with varying proportions of jaspery quartz, the rock *en masse* having a distinctly schistose appearance. Analyses have shewn the presence of, on an average, 46 per cent. of iron and 12 per cent. of manganese, and some samples contain considerably more than that quantity of manganese. "The manganese exists, in large part at least, in the form of psilomelane, occurring in irregular segregations, or more minutely disseminated through the rock."* The ore is less lustrous, more bluish-grey in colour, and its streak is less distinctly red than that of the micaceous variety of hæmatite previously referred to.

Conclusion.—The writer hopes that this paper may have served its purpose in creating some little interest in this ancient and historic metallurgical process. Perhaps, too, a fellow-feeling will be aroused by the remarks on the decline of the

* "The Iron-ores and Subsidiary Materials for the Manufacture of Iron in the North-eastern Part of the Jabalpur District," by Mr. F. R. Mallet, *Records of the Geological Survey of India*, 1883, vol. xvi., page 101.

To illustrate Mr F.H. Wynne's Paper on "Native Methods of Smelting" etc.

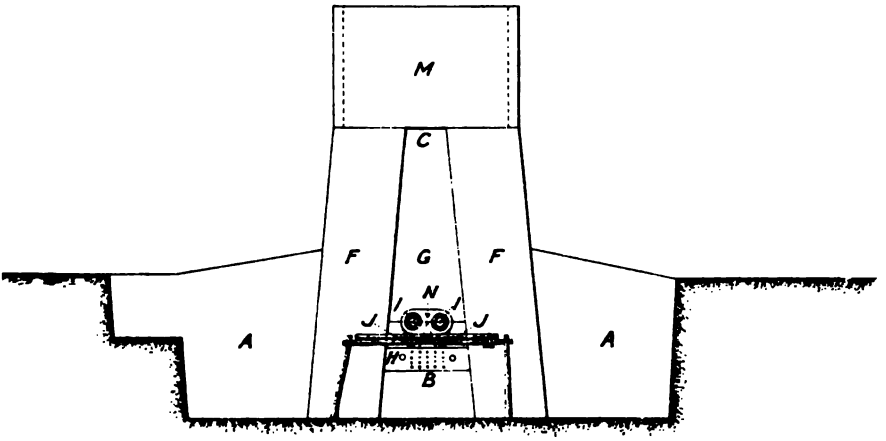


FIG. 8.—FRONT ELEVATION OF FURNACE.

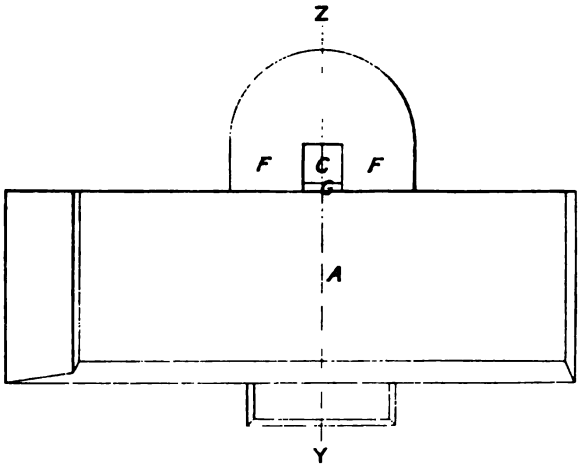


FIG. 9.—PLAN OF FURNACE AND TRENCH.

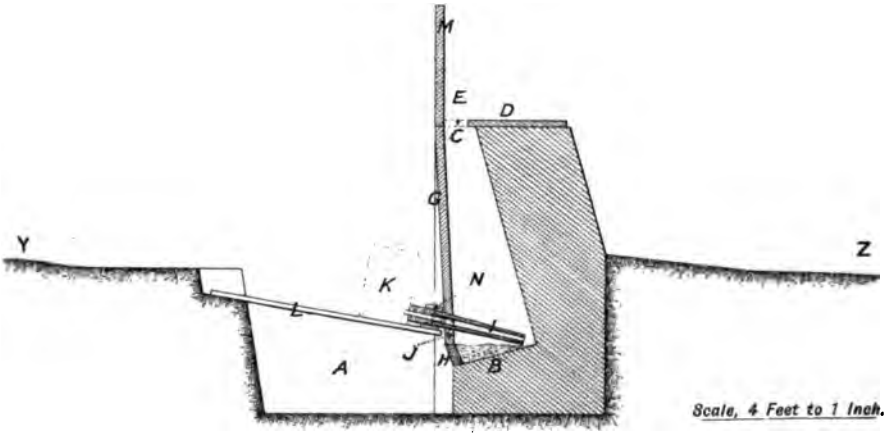


FIG. 10.—SECTION ON LINE Y Z OF FIG. 9.

industry, seeing that uncontrollable circumstances have lately caused some apparent falling-off in the prosperity of this branch of our trade, especially in North Staffordshire.

Mr. J. T. Stobbs asked whether Mr. Wynne would tell the members the geological age of the beds in which the micaceous hæmatite occurs, and whether he had formed any opinion as to the origin of the beds.

Mr. Thomas Peacock said that, some time ago, he was engaged on a railway near Kumasi, and, in excavations, they found remains of furnaces such as Mr. Wynne had described, but no iron was made in Ashanti now, so far as he could ascertain.

Mr. W. N. Atkinson asked whether Mr. Wynne could give the members information as to the manufacture of iron in India by modern methods.

Mr. F. H. Wynne believed that there was only one place in India, in Bengal, where iron was manufactured by modern plant.

Mr. W. Statham moved a vote of thanks to Mr. Wynne for his paper.

Mr. G. E. Lawton seconded the resolution, which was unanimously adopted.

DISCUSSION OF MR. JOHN CADMAN'S PAPER ON "THE OCCURRENCE, MODE OF WORKING AND TREATMENT OF THE IRONSTONES FOUND IN THE NORTH STAFFORDSHIRE COAL-FIELD."*

Mr. E. B. Wain asked Mr. Cadman whether the method of working the blackbands that he had described had been successfully adopted in the district. It seemed to him that, as compared with some methods that were adopted, the one that he had shown was much more workmanlike and should prove more satisfactory in practice.

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 89; 1902, vol. xxiii., page 50; and 1903, vol. xxvi., page 106.

Mr. W. Statham remarked that the system advocated by Mr. Cadman had perhaps been used as extensively at the colliery with which he was connected as anywhere in the district. The mines had been working for 15 years, 1,280,000 tons of raw stone and coal had been raised, and there had never been a fatal accident at the working-face and only one in the roadways. The most serious accident at the working-face had occurred to a collier who had his collarbone broken, and another had a broken leg. So far as economy was concerned, he thought that the system had proved very successful. The timber-cost was about 4½d. per ton of calcined ironstone, or, say, 2d. per ton of raw-stone. In opening the mine, on this plan, it lent itself to getting a large output; and they could put in more men, at an earlier date, than by other systems. They were satisfied with the system, and if he had to commence an ironstone-mine to-morrow he would commence on the system advocated by Mr. Cadman.

Mr. J. T. Stobbs thought it a remarkable fact that black-band ironstones, without exception, should be underlain by a seam of coal. He had no theory why there should be this connection, but evidently there must be some reason; and possibly a discussion might throw light on the question from a geological point of view. Mr. Cadman had pointed out the very erratic distribution of the clayband ironstone-seams, but he thought that a geological representative of each of the seams would be found over the whole area of the coal-field. Mr. Cadman had classified the Burnwood ironstone as a semi-blackband; he was of opinion that this seam would have been better classified as a blackband, but owing to its low position amongst the clay-band seams Mr. Cadman had probably found it convenient to deal with it in that part of his paper. At the same time, he thought that it was more closely allied to blackband than clay-band ironstone. Mr. Cadman had not mentioned the Rough-red mine, a blackband seam occurring near the base of the Etruria Marls.

Mr. W. Statham said that the Rough-red mine was of poor quality and thickness, occurring near Keele. It had been worked in conjunction with marl to the north-west of Silverdale vicarage.

Mr. E. B. Wain said that he agreed with Mr. Cadman's classification of the Burnwood ironstone. The seam was very erratic, and varied much in character. In his part of the district, it split up into two beds of distinct quality and condition: the lower portion being distinctly a clayband, and the upper more allied to blackband ironstone.

Mr. William Lockett said that the Burnwood ironstone and coal varied considerably in thickness in different parts of the coal-field. At Sneyd colliery, the band of ironstone averages about 11 inches in thickness and is found upon the Burnwood coal, and the latter varies from 3 to 4 feet in thickness. At Newchapel colliery, the ironstone and coal are separated as follows:—Ironstone, 1 foot to 1½ feet; press or bass, 2 feet; ironstone, 2 feet; inferior coal, 6 to 9 inches; strata, 9 to 12 feet; and the Burnwood coal-seam from 3 to 3½ feet.

Mr. J. T. Stobbs said that Mr. Lockett's observation confirmed his opinion that the Burnwood was a blackband ironstone.

Mr. M. H. Viggars asked whether Mr. Cadman would advocate the adoption of the longwall system, in an ironstone seam which was heavily watered.

Mr. H. Sumnall said that the longwall system had been worked to the rise with success in one of the heaviest watered mines in the district.

Mr. John Cadman, replying to the discussion, said that he was of opinion that, with few exceptions, the method which he had described was undoubtedly most successful and had been extensively used under many and varied conditions.

He (Mr. Cadman) was of opinion that blackband ironstone was originally deposited as a limestone, intermixed with carbonaceous matter, and that the lime had subsequently been replaced by iron. He was at present working on the subject, and he hoped to be able to produce evidence in support of his views in a future paper.

Mr. Stobbs had referred to the tracing and correlation of the ironstone-seams in the different parts of the coal-field; and he thought that Mr. Stobbs should be congratulated on the results of his labours in that direction. He (Mr. Cadman) had

classified the Burnwood ironstone as a semi-blackband, and he was still of opinion that his classification was correct. The Burnwood seam did contain carbonaceous matter, but not sufficient to bring about its own calcination; it was, moreover, erratic in character, and nowhere did he know of the seam occurring as a true blackband ironstone.

He (Mr. Cadman) would most certainly recommend the long-wall system for working seams, when heavily watered, because, the long series of working-faces being kept open, the water became disseminated along the whole of the workings, and consequently did not produce that excessive disintegration of roof and floor, experienced when working a heavily-watered mine by the pillar-and-stall system.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 12TH, 1903.

MR. W. O. WOOD, PRESIDENT, IN THE CHAIR.

DEATH OF MR. WILLIAM COCHRANE.

The PRESIDENT (Mr. W. O. Wood) referred in sympathetic terms to the death of Mr William Cochrane, who for many years had occupied a very honourable position in the Institute. He became a member in August, 1861; was Vice-President from 1870-1882 and 1884-1890; and President from 1890-1891. Mr. Cochrane had rendered great assistance to the Institute, and, at all times, took keen interest in its affairs. He (Mr. W. O. Wood) moved that a letter of condolence be addressed to the family of the late Mr. William Cochrane, expressing the great regret of the members at his death, and conveying their sympathy with them in their bereavement.

Mr. J. H. MERIVALE seconded the proposal, which was unanimously adopted.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on November 28th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

MR. WILLIAM RALPH BELL, Colliery Under-manager, Wearmouth Colliery, Sunderland.

MR. PERCY O. BONNIWELL, Chief Engineer, Engineering Insurance Department, Law Accident Insurance Society, Limited, 215, Strand, London W.C.

Mr. Charles Brent, Mining Engineer and Metallurgist, Rat Portage, Ontario, Canada.

Mr. Bourn Russell Chicken, Mechanical Engineer, 42, Sunbury Avenue, Jesmond, Newcastle-upon-Tyne.

Mr. Arthur Edwin Dixon, Geologist and Mine-manager, Hampson's Collieries, Waschbank, Natal, South Africa.

Mr. Charles Manning Donohoe, Mining Engineer, 28, Johnson Street, Lynn, Massachusetts, United States of America.

Mr. William Draper, Colliery Manager, Silksworth Colliery, Sunderland.

Mr. James M. Gummerson, Engineer, 35, Birkbeck Road, Acton, London, W.

Mr. Arthur Morton Hedley, Mining Engineer, Blaydon Burn, Blaydon-upon-Tyne.

Mr. John Hogg, Mechanical Engineer, Thornley Colliery Office, Thornley, R.S.O., County Durham.

Mr. Christopher Hunter, Mechanical Engineer, Cowpen Colliery Office, Blyth, Northumberland.

Mr. Frederick Ernest Jacob, Mining Engineer, Westbrook, Swansea.

Mr. James Johnson, Sinking and Boring Contractor, Boldon Lodge, East Boldon, *via* Newcastle-upon-Tyne.

Mr. Frank Little, Electric-power Engineer, Ward's Buildings, High Bridge, Newcastle-upon-Tyne.

Mr. Benjamin Francis McDowell, Mining Engineer, P.O. Box 10, Macequece, Portuguese East Africa.

Mr. James Heppell Marr, Mining Engineer, Malton Colliery, near Durham.

Mr. Herbert William Middleton, Colliery Manager, Trimdon Colliery, R.S.O., County Durham.

Mr. Frank Percy, Engineering Lecturer and Consulting Engineer, Mining College, Wigan, Lancashire.

Mr. John Robinson, Colliery Manager, Longhirst Hall Colliery, near Morpeth, Northumberland.

Mr. John Scorer, Mechanical Engineer, Barakar, E.I. Railway, Bengal, India.

Mr. Ralph Storey Swallow, Colliery Manager, The Garth, Medomsley, R.S.O., County Durham.

Mr. John Fox Tallis, Mining and Civil Engineer, The Firs, Ebbw Vale, Monmouthshire.

Mr. John Thomas Tennant, Inspector of Collieries, James Street, Hamilton, Newcastle, New South Wales.

Mr. Joseph Thompson, Colliery Manager, North Biddick Colliery, Washington Station, County Durham.

Mr. James Tinsley, Colliery Manager, Bridge House, Ebbw Vale, Monmouthshire.

Mr. Robert G. Ware, Superintendent, Vinton Colliery Company, Vintondale, Pennsylvania, United States of America.

Mr. Robert Gott Wilson, Colliery Manager, Whitehill Terrace, Pelton Colliery, Chester-le-Street, County Durham.

Associates—

Mr. Henry Armstrong, Overman, 41, Church Street, Murton Colliery, *via* Sunderland.

Mr. George Arthur Hawes, Deputy and Science Teacher, 34, New Pilgrim Street, Murton Colliery, *via* Sunderland.

MR. WILLIAM OLIVER, Deputy-overman, 14, Model Street, New Seaham, *via* Sunderland.

MR. THOMAS SCHOLLICK, Back-overman, 21, Hall Street, New Seaham, *via* Sunderland.

MR. MAURICE HEWSON WILKINSON, Overman, Medomsley, R.S.O., County Durham.

STUDENTS—

MR. THOMAS BLANDFORD, Mining Student, Deaf Hill Colliery, Trimdon Grange, R.S.O., County Durham.

MR. GEORGE HAROLD GREENWELL, Mining Student, 4, Ivy Avenue, Ryton-upon-Tyne.

MR. ANDREW KIRKWOOD MCCOSH, Jun., Mining Student, Coundon, Bishop Auckland.

MR. ROBERT A. PURVIS, Mining Apprentice, Inglethorpe, Harton, South Shields.

SUBSCRIBER—

MESSRS. A. GOERZ & COMPANY, LIMITED, 20, Bishopsgate Street Within, London, E.C.

DEATH OF MR. A. L. COLLINS.*

The following letters were read:—

NEWCASTLE-UPON-TYNE,
July 9th, 1903.

Sir,

With further reference to my letter of February 7th, and your reply thereto of April 21st, 1903, I enclose herewith extract from the issue of the *Engineering and Mining Journal* (New York) of June 27th last referring to the murder of Mr. Arthur L. Collins at Telluride in November last. †

The Council trust that the British Ambassador to the United States may be instructed to use every endeavour in order that the perpetrators of this murder may be brought to an early trial.

I have the honour to be, Sir,
Your obedient Servant,
M. WALTON BROWN,
Secretary.

The Right Honourable the Secretary of State,
Foreign Office, London, S.W.

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 288.

† TELLURIDE AGAIN.—After the assassination of Arthur L. Collins, last November, a spirit of opposition to disorder and lawlessness caused the citizens of Telluride, Colorado, to demand legal action. A grand jury was called, and a number of men were indicted as having been privy to the murders and riotous assaults, which have disfigured the record of a splendid mining district. Now comes the sequel. When court met recently, the sapient judge announced that he had called the grand jury last December in an irregular manner. All the indictments were quashed. This happened late on a Saturday night. On the Sunday following it was understood that the *District-attorney* was preparing new indictments. A tremendous snowstorm, terrible even for that mountainous

FOREIGN OFFICE,
October 22nd, 1903.

SIR,

With reference to the letter from this office of the 17th of July last, I am directed by the Marquess of Lansdowne to transmit to you a copy of a letter, which has been received through His Majesty's Embassy at Washington, addressed by the *District-attorney* of Colorado to the Governor of that State, and giving an account of the efforts which have been made to trace the persons guilty of the murder of Mr. A. L. Collins at Telluride.

From this letter you will see that the efforts of the local authorities to discover the guilty parties have so far been unsuccessful. Lord Lansdowne gathers, however, from the last sentence that those efforts will not be relaxed, and on the receipt of any later information on the subject a further communication will be addressed to you.

I am, Sir,
Your most obedient humble Servant,
CHARLES HARDINGE.

The Secretary to the North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

September 26th, 1903.

SIR,

Further answering your respected favour of September 8th, 1903, concerning the assassination of Mr. Arthur Lancelot Collins at Telluride, Colorado, I beg herewith to quote statement made to me under date of September 21st, 1903, by Mr. Edward C. Howe, my deputy district-attorney at Telluride, Colorado, for San Miguel County, as follows:—

"Replying to your favour of September 14th, in which you ask what efforts have been made to ascertain the identity of the murderer of Arthur L. Collins, I have to say that I believe every reasonable effort that could be made has been made, and that everything that could be done has been done. The State offered a reward of 2,000 dollars, and the County offered a reward of 10,000 dollars, for information leading to the arrest and conviction of the murderer. Numerous rumours and clues have been furnished to me from various sources; some seeming very mythical, and others appearing to have some foundation. Each of them, however, has been investigated, whether the same seemed to merit investigation or not. I have in person made trips to Durango, Rico, Ouray and other places in connection with these matters. We sent one man clear to Southern Arizona in connection with it. Also private investigations have been made, but so far nothing has been accomplished towards identifying any particular party with it.

region, came on; and in the teeth of it, those who had been indicted fled across country, catching the train at various points and so escaping.

Such happenings as this make a fool of the law and constitute an impertinence to justice. So long as criminals can get the best legal talent arrayed on their side, while the law of the land is administered and upheld by men competent only for political office and for positions which are the reward for political activity, so long will there be a premium on lawlessness in our mining regions.

There is only one remedy for this state of affairs, and that is enlightened public opinion. If the good men in the community are afraid to speak out, save when they feel an occasional spasm of civic virtue, then there is little likelihood of the development of a healthy reprobation of such methods. And this applies to larger communities, no less than to a mining settlement like Telluride.—*The Engineering and Mining Journal* [New York], June 27th, 1903.

The only evidence in connection with it, which has been found, was the finding of a repeating shot-gun, commonly known as a "pump-gun," which was found on the banks of Royer Creek this spring, after the snows melted, which contained two or three shells loaded with buck-shot, and of the same style and calibre as the shell found in the yard after Mr. Collins was shot; but further than this I have nothing to report, which can be considered as evidence in the matter at all."

I can add no further information to this statement. Your Excellency is well aware that The Smuggler Union Mine had its office at Pandora, some distance outside of the town of Telluride, at the time Mr. Collins was killed there, and was outside of police protection. There could not have been a better place for an assassination than that, because the chances of detection were few on account of the situation.

While the officers have suspicions as to who were the instigators of this killing, these suspicions have not been verified by any positive evidence to date and consequently it would not be proper to state what they are.

I beg to assure Your Excellency that the killing of Mr. Collins was universally condemned in that community, outside of the class which had antagonized him, and that the entire local government of San Miguel County has been keenly alive to the responsibilities imposed upon it by this situation, and no effort has been or will be relaxed by any officer to bring to justice the perpetrators of this assassination.

Yours very truly,

S. G. McMULLIN,

District-attorney.

His Excellency James H. Peabody,
Governor of Colorado,
Denver, Colorado.

DISCUSSION OF THE "REPORT OF THE COMMITTEE UPON MECHANICAL COAL-CUTTING."*

Mr. T. W. BENSON (Newcastle-upon-Tyne) asked whether there was any advantage in using coal-cutting machines in long-wall working, in a seam varying from 28 inches to 30 inches in thickness, if hewers were getting by hand-holing from 3 to 3½ tons per day, at a tonnage-price of 1s. 3d. to 1s. 6d., and where the difference in selling price—between round and small coal—was say 2s. 6d. to 3s. per ton.

Mr. J. B. ATKINSON (H.M. Inspector of Mines, Newcastle-upon-Tyne) mentioned that in the neighbourhood of Airdrie, in Scotland, the Lower Drumgray, a valuable seam of house-coal, 30 inches thick, had been for 10 or 15 years worked almost entirely by coal-cutting machinery, principally on account of the increased percentage of round coal obtained.

* *Trans. Inst. M.E.*, 1903, vol. xxvi., page 141.

Mr. T. E. Forster (Newcastle-upon-Tyne) said that all the conditions would have to be taken into account, and he was afraid the Committee could hardly invent a formula to ascertain the tons which would be produced from a given seam, but if Mr. Benson would give full particulars as to the physical conditions he would endeavour to answer the question.

DISCUSSION OF MR. A. A. ATKINSON'S PAPER ON "WORKING COAL UNDER THE RIVER HUNTER, ETC."*

Mr. R. H. Brown (Halifax, Nova Scotia) wrote that as he had had the management for many years of one of the collieries mentioned by Mr. Atkinson, a few particulars connected with the practice of undersea working thereat, may be of some interest to the members. The Old Sydney mines are situated on the eastern coast of the island of Cape Breton, Nova Scotia, and it was the first mine in America to begin the working of coal under the waters of the Atlantic Ocean. The General Mining Association, London, were the owners of this colliery, until it was sold some three years ago to the Nova Scotia Steel and Coal Company, the present proprietors.

The coal worked is known as the Sydney Main seam, it averages between 5½ feet and 6 feet in thickness of coal of the best quality, dips in a north-easterly direction towards, and under, the ocean at an inclination of 1 in 12, while the strike is north-west and parallel with the general direction of the shore-line (Fig. 1). The floor, under the coal, is a fire-clay, and the immediate roof is sometimes of sandstone, and in some districts of shale or till, which falls readily at times, and is difficult to support with timbering. The seam is remarkably exempt from faults or slips of the strata, and occasionally rolls, or depressions occur in the roof, reducing the thickness of the seam over small areas. In the dip-workings, a thin seam of coal, from 6 to 12 inches thick, occurs in the strata about 8 feet above the main seam. The Princess and winding-shaft is sunk near the sea-coast, and is 687 feet in depth. Very little inflammable gas is met in working; but, as a precaution, only locked safety-lamps have, for some years past, been used.

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 622.

The working of the coal, under the sea, was commenced in April, 1877, under a cover at the shore-line of 690 feet of solid measures, although a portion of the workings, driven to the rise, under Sydney Harbour, was operated under a cover of 500 feet or less. The method of working was bord-and-pillar: the levels and winning-places were driven 6½ feet wide; the rooms or bords were 17 feet wide, their course being parallel to that of the levels; and the cross-cuts, through the pillars, were driven 9 feet wide. The pillars were left 40 feet wide and 123 feet long.

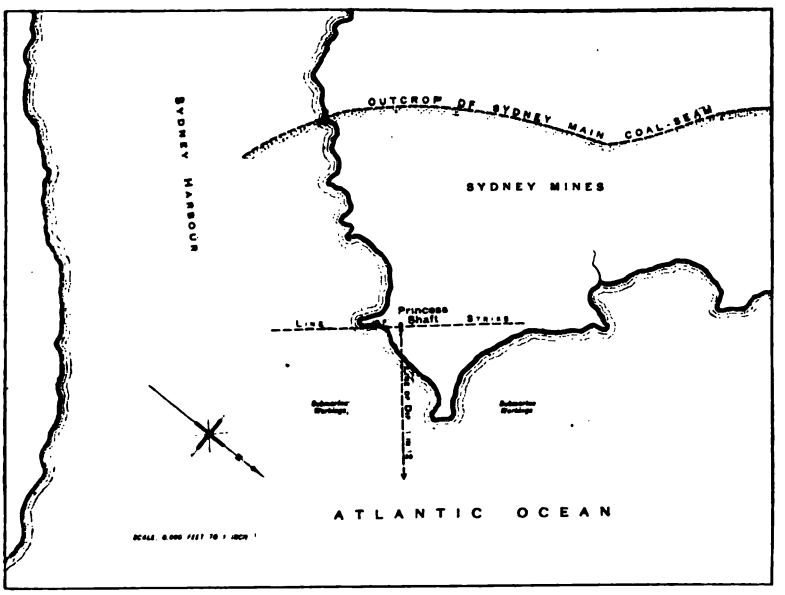


FIG. 1.—SKETCH-PLAN OF THE OLD SYDNEY MINES.
SCALE, 6,000 FEET TO 1 INCH.

The present faces of the workings have reached a distance from the shore-line of 5,800 feet to the dip. Here the overhead-cover is 1,140 feet thick of rock, with 33 feet depth of water above, this depth increasing to 37 feet at high tide. The levels, deeps and headways are now driven 8 feet wide; the bords are still 17 feet wide, and the cross-cuts, 9 to 12 feet wide. The pillars being left now are 66 feet wide and 148½ feet long.

The undersea workings in the whole coal at present cover an area of more than 1,620 acres, with an overhead cover averaging 900 feet of strata, and 18 feet of sea-water above.

For many years, the Company hesitated to begin the working of the pillars in this submarine lease, and contented themselves with

the intention of bringing back the pillars from the extreme faces, after the whole coal should have all been won. A very large area of pillars was thus left standing, and that, in some instances, for many years. However, it was eventually decided to commence working the pillars in a tentative way; and in January, 1899, a beginning was made by removing the pillars at two or three suitable points in the workings; and, at present, pillars are now being worked in six or seven districts of the mine. During September, 1899, the getting of coal by the longwall method was also inaugurated in a district of the mine, where there was a small area of low coal; the cover overhead here was about 1,000 feet thick.

Up to the present time, the pillars have been successfully removed from an area of 55 acres: almost all of the coal being got. Some 438,000 tons of pillar-coal have thus been taken; while from the 7 acres of whole coal, worked by longwall, some 46,000 tons of coal have been produced. Slight crushes, or creeps of the floor, were developed in two or three of the bord-and-pillar districts, but they were only local in effect. Where the roof comes down freely after the removal of the pillars, the falls do not seem to extend to a height of more than 10 or 12 feet above the seam, and the falling strata generally include the thin seam of coal already mentioned.

No sea-water has found its way into the workings as a result of the working of the pillars. Some workings driven to the rise in the whole coal-working produced a feeder of a few gallons of water per minute: this had evidently followed the seam of coal downward from a point where it cropped out under the waters of the harbour. No water has been known to come from overhead across the measures, and this immunity from leaks is probably due to the presence in the overhead strata of twelve beds of under-clay, or fire-clay, of an aggregate thickness of 36 feet 10 inches, as well as to the numerous beds of shale of more or less softness, which occur throughout (Table I.).

The subsidence due to the removal of a bed of coal, 6 feet thick, would probably, under these conditions, soon choke itself, so that there would be no actual settling or motion of the strata for more than 100 feet above the seam; and above that point the elasticity of the beds, already mentioned, would prevent any rupture. The condition of the immediate sea-bottom need

not be taken into consideration, at least in his experience, nor did the presence of a bed of clay thereon seem necessary to prevent the influx of water. The sea-bottom is rock, over the workings at the Old Sydney mines. The sandstones do not afford any protection, and a reference to the accompanying section of the strata passed through in sinking the Princess shaft (Table I.) shews that the 33 feet of sandstone encountered at a depth of 270 feet below the surface, and about 220 feet below sea-level, contained cracks and cutters, which allowed an influx of 650 gallons of sea-water per minute, into the shaft. This feeder probably followed the sandstone from its outcrop some 1,300 feet away under the water of Sydney Harbour. It was overcome, by tubbing the shafts from the surface downward for 300 feet.

TABLE I.—SECTION OF STRATA SUNK THROUGH IN THE PRINCESS PITS, OLD SYDNEY MINES, CAPE BRETON, NOVA SCOTIA.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Soil, sandstones and shales ...	81	3	81	3
	Lloyds Cove Seam.				
2	**COAL**, with 6 inches of clay-band	6	8	87	11
3	Sandstones and shales	172	5	260	4
4	**COAL**	0	3	260	7
5	Under-clay and shales	9	6	270	1
6	Sandstone, hard, with cracks and cutters, salt-water feeder, 650 gallons per minute	33	0	303	1
7	**COAL**	0	9	303	10
8	Under-clay, soft	1	10	305	8
9	**COAL**	0	8	306	4
10	Under-clay, strong	5	0	311	4
11	Shale, mixed with *coal*	1	3	312	7
12	Clay, soft ...	0	4	312	11
13	Shale, with *coal* at bottom	1	10	314	9
14	**COAL**	0	9	315	6
15	Under-clay and shale	1	10	317	4
16	Sandstone, strong, dark grey ...	10	8	328	0
17	Shale, soft, dark	3	2	331	2
18	**COAL** and shale mixed	0	10	332	0
19	Under-clay ...	3	0	335	0
20	Sandstone, slaty, with ironstone-nodules. — *Lepidodendron* and ferns in the partings... ..	16	9	351	9
21	Shale, hard blue, with ironstone. —*Sigillaria* and ferns	4	0	355	9
22	**COAL**	1	2	356	11
23	Clay and black shale	0	5	357	4
24	**COAL** and shale mixed	0	10	358	2
25	Clay, soft ...	0	9	358	11
26	Shale. black ...	0	4	359	3
27	Under-clay, strong, sandy. — *Stigmaria*-rootlets	4	0	363	3
28	Sandstone, fine grained, ironstone-nodules with quartz-crystals ...	6	2	369	5
29	Shale, soft, blue ...	8	8	378	1
30	**COAL**	0	2	378	3
31	Under-clay ...	2	0	380	3
32	**COAL**	0	3	380	6
33	Under-clay, with ironstone - nodules.—*Stigmaria*-rootlets ...	1	4	381	10
34	Shales, grey, slaty, with ironstone-nodu'es ...	3	2	385	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
35	Shales, grey and bluish, soft ...	7	8	392	8
36	Sandstone, grey, hard ...	8	3	400	11
37	Shales, blue, grey and red, 10 beds	50	3	451	2
38	Sandstone, hard, with cleavage-planes	23	0	474	2
39	Shales, blue and black, 8 beds ...	35	10	510	0
40	**COAL**	0	5	510	5
41	Shale, sandy, and sandstones, mixed	11	6	521	11
42	Shales, red and greenish ...	4	8	526	7
43	Sandstone or strong slaty shale ...	10	10	537	5
44	Shale, red ...	1	0	538	5
45	Sandstone ...	3	3	541	8
46	Shale, red ...	9	5	551	1
47	Sandstone, hard	12	6	563	7
48	Shale, blue, soft.—*Calamites*, reeds and threads of *coal* at bottom	15	7	579	2
49	**COAL** and shale, mixed irregularly	1	5	580	7
50	Shale, strong, sandy	4	7	585	2
51	Under-clay ...	3	3	588	5
52	Shale, blue, sandy	5	7	594	0
53	Sandstone ...	9	7	603	7
54	Shales, blue and black. — *Calamites* at top ...	5	9	609	4
55	Sandstone, hard ..	1	0	610	4
56	Shales, blue and black, 4 beds.—*Lingula* - shells and coprolites ...	9	11	620	3
57	Under-clay, grey, crumbly ...	9	6	629	9
58	Sandstone, hard, grey	31	7	661	4
59	Sandstone and hard blue shale ...	4	0	665	4
60	Sandstone, slaty, carbonaceous partings ...	2	6	667	10
61	Sandstone, strong, white	5	1	672	11
62	Sandstone, strong, numerous black partings. — *Calamites* and *Lepidodendron* near bottom ...	8	1	681	0
	Sydney Main Seam.				
63	**COAL**	6	0	687	0

DISCUSSION OF MR. W. LECK'S PAPER ON "AMBULANCE-INSTRUCTION AT MINES."*

Surgeon-Major GEORGE A. HUTTON (Honorary Organizing Commissioner of the St. John Ambulance Association) said that he desired to revive ambulance-work in all the mining-districts of the country, and to ask the members to support his recommendation, that every colliery and mine should have its ambulance-class. It was not sufficient that a few men, here and there, should know what to do with an injured man, but that every man, who had the time and opportunity should endeavour to gain first-aid knowledge. Before he went further, for the benefit of those present who might not be very clear as to the nature of ambulance-work, he wished to explain its true object and meaning. For instance, a collier in a pit had his leg broken by a fall of stone, his comrade who was next to him was an ambulance-man, and by means of a simple improvised splint and bandage, was able to put up the injured limb, and then, with

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 354; and vol. xxvi., page 154.

a proper stretcher (kept down the pit), he and his companions removed him to bank, and to his own home or hospital without danger of making the injury worse by ignorant though kind handling, as was often done. Again in another colliery, several men were badly burnt, and the ambulance-men were able to render useful and valuable assistance in dressing the burns. In another case, an artery was wounded in the thigh, but the ambulance-man knew how, and where, to apply the pressure to stop the bleeding, and so life was saved. He (Major Hutton) remembered, some years ago, visiting an hospital in Lancashire, and a man was admitted whose leg had been nearly cut off. In this case, an ambulance-man had stopped the bleeding, and saved life, and then the man had been carefully carried a distance of 2 miles to the hospital, and thus spared a vast amount of pain and suffering. This case was a typical example of ambulance-work—the saving of life by the arrest of bleeding, and the alleviation of pain by careful transport; and these two cardinal points—the saving of life and the alleviation of pain, should be engraven in letters of gold in the hearts and memories of all ambulance-workers. And here, he too would remark for the information of the members of the medical profession, that they simply sought to render first-aid; and that they always impressed upon all pupils, that whenever they were called upon to render assistance, whether in broken bones, burns, bleeding, etc., they were never or any occasion to omit sending for the doctor. These instructions have been so carefully carried out, that no complaints have been made by any doctor—on the contrary, the members of the medical profession, all over the country, have given a loyal and active support to the movement.

Another point, upon which he (Major Hutton) held a strong opinion, was uniformity of instruction and examination, and the benefit of belonging to the St. John Ambulance Association. Miners may be said to amount to a big army of workers, and in these days of rapid locomotion, men migrate frequently from one district to another. If they are instructed in first-aid and the removal of the injured, under one well-organized system, the ambulance-men from different districts will at once understand each other, and as the St. John Association has branches all over the country, the value of uniform action in cases of injury, must be clear to everyone who values

good work. He (Major Hutton) might add that the work had now taken root in many of the Colonies, in British India, Australia, New Zealand, and he hoped that there would be a great development of ambulance-work, when South Africa became more settled.

All young men going to the Colonies, especially mining and mechanical engineers, should qualify themselves to render first-aid under the St. John Ambulance Association. He (Major Hutton) had served in South Africa for 4 years, and knew how valuable and useful such knowledge was in a country where it was often difficult to procure proper medical aid, and where the patient might have often to wait for many days or weeks before any doctor could be procured.

One material point in ambulance-work is, that it is voluntary. From experience in public matters, extending over a long number of years, he (Major Hutton) felt that the work was much better carried on by voluntary means, than by any Government department. When the Coal-mines Regulation Bill of 1887, was under discussion, he favoured what is now the rule (No. 34) that stretchers should be kept at every colliery, but that the instruction in first-aid should be entirely voluntary. He felt sure that the good sense of the men would not be slow to see the value of the instruction, and they would gladly avail themselves of it.

As far as St. John Ambulance work was concerned, he (Major Hutton) had no desire, as a practical man to theorize, nor to appeal to mere popular feeling on this question. He asked that every mine and colliery should be supplied with proper ambulances and stretchers, and for the men to be instructed in their use and to render first-aid. He asked the owners, managers and all in responsible positions to aid in spreading this knowledge; and lastly he called upon the men to assist themselves by attending the classes, which he trusted might soon be revived and extended at all collieries and mines. He felt sure that he would not appeal in vain for co-operation and support in the humane work of the St. John Ambulance Association.

The PRESIDENT (Mr. W. O. Wood) remarked that it was the rule at the South Hetton collieries, that deputies and overmen should attend ambulance-classes, but difficulty had been experienced in inducing hewers and stonemen to take an interest

therein. He suggested that the officials of the workmen's associations should be asked to take an interest in the ambulance-classes and to direct the attention of the lodges at the various collieries to the importance of obtaining instruction.

Mr. R. Donald Bain (H.M. Inspector of Mines) said that practically the whole of the collieries in the Durham mines-inspection district had joined the newly formed Ambulance League and the district comprising South Durham, Westmoreland and North Yorkshire had been divided into 10 centres. The members of each team would in the first place receive a certificate from the St. John Ambulance Association; the teams from the mines attached to the local centres would compete amongst themselves; and finally the 10 teams representing the local centres would compete at Durham for a challenge-shield. He hoped, with the assistance of a representative committee, that there would be at least 2,000 men under instruction in each year, and that the movement would be a lasting one. He had recently mentioned this matter to Mr. John Wilson, M.P., and that gentleman had volunteered to refer to it in the *Monthly Circular* issued to the members of the Durham Miners' Union.

Mr. William Leck (H.M. Inspector of Mines) drew attention to one of the suggestions in his paper that "managers might make it known that no young man would be considered qualified for promotion to the rank of a miner, unless he is in possession of the certificate or medallion, the qualifying badge of the St. John Ambulance Association. This has been done with happy results in at least one of the hæmatite-mines of Cumberland."

Mr. A. L. Steavenson (Durham) pointed out that the question appealed to them on two grounds:—(1) On that of humanity, as no one would like to be lying with a bleeding artery or a broken limb, without anybody being able to afford them the slightest assistance; and (2), there was the sordid monetary view; if a man had a broken leg it might become much worse, if he did not receive proper attention at once. Colliery-managers ought to select their deputy-overmen, as far as possible, from men who held ambulance-certificates; the deputies were always in the flat, and if an accident happened they would

be in attendance within 5 minutes. It had been suggested that no one should be allowed to sit for a certificate to manage a mine unless he held the certificate of the St. John Ambulance Association. However, many men lived at a distance from where lectures were delivered, and, therefore, it would be impracticable to make such a restriction, but he was in favour of marks being awarded for such an ambulance-qualification.

Mr. J. B. Atkinson (H.M. Inspector of Mines) said that Major Hutton favoured voluntary work in promoting ambulance-instruction. The Coal-mines Regulation and Quarries Acts required that appliances should be kept for ambulance-work, and it would be logical to go a step further and require that a certain class of men should acquire the necessary knowledge to make use of these appliances. It had been suggested, as Mr. Steavenson had mentioned, that ambulance-knowledge should be required in connection with colliery-managers' certificates; and the question had been brought before the Examination Boards in the various mines-inspection districts at the instigation of the Home Secretary. Managers might require that under-officials should hold ambulance certificates, and some form of compulsion should be adopted to secure a sufficient number of ambulance-men at collieries. The ambulance-certificate could be obtained after attending a course of five lectures, and there was no difficulty in any ordinary man securing the necessary qualifications.

Mr. J. H. Merivale (Broomhill) said it had been mentioned that colliery-owners and managers had always been in favour of ambulance-classes, but colliery-doctors ought also to be mentioned. In his own experience, colliery-doctors were most willing and kind, and there was no difficulty in persuading them, in most cases without fee, to devote a certain amount of time to the promotion of this most useful object. The great difficulty was the extraordinary conservatism of the North-country pitman. It would be an excellent plan, and quite feasible, if colliery-managers would follow the example of the President, and insist that overmen and deputies should hold ambulance-certificates. He thought that the examiners were perfectly justified in insisting on some knowledge of ambulance-work from candidates for colliery-managers' certificates; and in

Northumberland the examiners had been in the habit of asking questions on the subject, and awarding marks to the men who answered them satisfactorily.

Mr. W. Walker (H.M. Inspector of Mines) remarked that Mr. R. D. Bain had kindly given a challenge-shield to the Ambulance League that had been formed in the Durham mines-inspection district, and he hoped that the competition for it would be the means of encouraging the formation of ambulance-classes. It was also proposed that a sum of money should be given to each team that participated in the final competition, and the first and second teams would also receive medals. If all officials were required to hold ambulance-certificates, more interest would be taken by the men, especially by those who desired to be promoted. He thought that all deputies and waggon-waymen should hold ambulance-certificates, as they were, in most cases, the nearest officials to any workmen in a mine, when an accident happened.

Mr. J. G. Weeks (Bedlington) remarked that there was no necessity for compulsion or stimulation, at all events, at collieries in Northumberland. Ambulance-instruction had been given at the Bedlington collieries since 1885, and on several occasions Surgeon-Major Hutton had examined and addressed the classes. Stonemen, hewers, putters, drivers, and also the men's wives joined, in fact they had a large class of ladies. At the Bedlington collieries, even animals that had broken a leg had been put into splints. The classes had always been very popular.

Mr. A. L. Steavenson, referring to the observations of Mr. Atkinson, said that if the holding of ambulance-certificates were made imperative, funds must be provided by the Government for the payment of the doctors, who taught the classes. At the collieries belonging to Messrs. Bell Brothers, Limited, the doctors were paid, he thought, a fee of £2 2s. for a course of lectures, but he did not suppose that all colliery-owners would be willing to bear this charge.

Mr. C. H. Steavenson (Redheugh) suggested that ambulance-corps might be placed on a similar footing to volunteer corps, and the Government might be induced to give a grant for each proficient member.

Mr. F. Coulson (Sherburn) suggested that a list of the men, who held ambulance-certificates, should be posted in some conspicuous spot. In his own experience, a man had been injured within a short distance of another who was qualified to render first-aid, but his proficiency was not known at the time, and his services had not been utilized.

Surgeon-Major Hutton said that he was entirely opposed to compulsion in the matter. He favoured the General Rule, No. 34, in the Coal-mines Regulation Act, requiring that stretchers and ambulance should be provided, but he thought that instruction should be left to the good sense of the men. With reference to the examination for colliery-managers' certificates, the Examination Board for the Midland mines-inspection district did not compel the candidate to hold the certificate of the St. John Ambulance Association, but the candidates were given a few questions on the subject of ambulance. He knew that it was a general rule in the Midland district to require a man, who sought to be promoted, to hold an ambulance-certificate.

Mr. G. H. Kinahan's "Notes on Mining in Ireland" were read as follows:—

NOTES ON MINING IN IRELAND.

By G. H. KINAHAN, M.R.I.A., District Surveyor (Retired), H.M. Geological Survey, Ireland.

Introduction.—Mining and the winning of metals is now on a different basis from what it was in the last century. Chemistry and other sciences have been successfully introduced, so that poor ores, formerly valueless, can now be worked with more or less good prospects. On this account, some of the abandoned mining properties, supposed to be economically valueless, may now be worked to profit. This statement does not apply to all the abandoned mines, as for some there are no hopes: such as the pockets of lead-ore in the Carboniferous Limestone, that had definite limits. However, as these pockets are on special geological horizons, it is possible that other pockets, now unknown, may exist; but as there are no leads, or such like indications of the proximity of one pocket to another, looking for an unknown pocket is very like searching for a needle in a bundle of hay. The pockets now worked out usually had surface-indications, though a few of them were discovered by chance. Furthermore, elsewhere some of the regular mineral lodes that were once famous for their riches seem to have had their riches solely stored in the portions that are now exhausted.

It is remarkable how chance, if we may so call it, comes in to aid science. In the Transvaal the "banket" or "almond-rock," is a low-grade ore, seldom assaying much more than ½ ounce of gold to the ton. In mining, they have to bring up good with "dead-stuff," and at first all brought up was passed through the mills, which took considerably from the profits. The Kaffir boys, however, who have better eyesight than the whites, could detect the "pay-stuff" from the "dead-stuff," so now there is a sorting process; the ore after being wetted, is passed down on to a revolving table, and the boys, as the stuff revolves slowly past, pick out the barren pieces and throw them away.

According to popular belief, at the Ovoca mines, county Wicklow, the mode of recovering copper in solution was also due to chance. A miner stole a shovel, and hid it in a stream of the water pumped from the mine. Until the loss of the shovel was blown over, he did not go to take it away, and when he did, instead of an iron he found a copper shovel. Of course the "de'il was in the shovel;" and for a time he was rather uncomfortable, but at last he told his wife, who advised him to "make a clean breast to the master." The master having seen the shovel, had a barrow-load of old shovels thrown into the stream. This is the story as told in connection with the Ballygahan mine, but it is possible that the discovery may have been made elsewhere. At all events, the owner of the mine erected banks of launders in which scrap-iron was put to recover the copper in solution. The process was so successful that other mine-owners in the district followed his example. It is an inexpensive way of making a profit; as the only large expenses arise from the erecting of launders and the laying in of a store of scrap iron. There is an exhaustive paper on the subject by Messrs. Philip Argall and Gerrard A. Kinahan* in which the original process and later improvements are described. A process that has also been proposed is the erection of collecting-vats, and concentrating by chemical reactions the copper in the carbonates. Such a manipulation would be most costly, while with the Ovoca process pure or nearly pure copper is the result at a minimum cost.

The separation of ores by magnetism is an important aid in cleaning and dressing, as thereby ores that formerly could not be separated by the different dry and wet methods in vogue, are now amenable. The process is based upon the fact that substances behave differently under the influence of a strong magnetic current. The following minerals may be sorted out by magnetic separators:—(1) Magnetic ores: all iron-ores; compounds of titanium, tungsten, nickel, cobalt and manganese; oxidized and sulphide ores of copper, and certain sulphides of zinc. (2) Non-magnetic ores: lead-ores, silver-ores, tin-ores, and compounds of bismuth.

* "Notes on the Recovery of Copper from its Solution in Mine-drainage, with Special Reference to the Wicklow Mines," *Scientific Proceedings of the Royal Dublin Society*, new series, 1882, vol. iii., pages 302-328.

Magnetic separators are successful in Cornwall for separating wolfram from tin-ore; and in Italy for separating blende and copper-ores.

Engineers acquainted with Irish ores must at once see the great gain to be wrought in the winning and separation of ores, as admixtures now unprofitable (the expense of the chemical processes that have been tried far exceeding the value of the results) should by magnetic separation yield profitable results.

In these notes, it is proposed, as a preliminary, to mention the minerals or their ores, that at one time or another, gave a name to Ireland, on account of the revenues that accrued from their winning and manufacture; but these industries are now more or less obsolete, not on account of the minerals or their ores being exhausted, but on account of the very different circumstances prevailing now compared with those formerly existing. Among these standing out prominently are (1) gold and iron; and (2) silver and copper.

The present prospects of metal-mining will afterwards be briefly considered.

Gold.—Gold, at one time, must have been a staple export from the island; yet most of the early English historians would have us believe that all the Irish gold was imported in exchange for slaves. But more extraordinary still, in spite of ocular evidence to the contrary, quite recent writers have attempted to regenerate this canard. Dr. Gerrard Boate, who wrote in 1641,* would have us believe that before the English came the natives knew nothing of metallurgy: yet -- Chichester in his report of 1609, was specially impressed with the superiority of the work of the Irish smiths over those of England. In place-names the work of the smith and artificer also are recorded.

The earliest record of Irish gold-workers seems to be the discovery of a settlement under the Bog of Cullen, near the boundaries of Tipperary and Limerick. The circumstances connected therewith prove that it must have been very ancient.† These artificers had their settlement in a wooded hollow, which was suddenly flooded either artificially or naturally, as all their implements were found just as left after a sudden flight.

* *Ireland's Natural History*, 1652, page 124.

† *Manual of the Geology of Ireland*, 1878, pages 339-346.

This flood killed the wood, a bog growing in its place. On this bog other trees subsequently grew, this second wood being also flooded and replaced by the recent bog. We therefore have four periods:—(1) The colony in the wood, (2) the first bog, (3) the second wood, and (4) the recent bog. It is hard to calculate how long the two bogs, respectively, took to grow, or how long the second wood lasted; but many ages must have passed since the gold-smelters lived in the wooded glen of Cullen. The genealogy of a family of goldsmiths is given in the *Book of Lismore*. They were descended from Olioll Olum, king of Munster, and followed the trade uninterruptedly for seven generations, from about 300 to 500 A.D.* In olden times, the plain of the Liffey was called Laighnigh-an-oir from its gold. According to the *Annals of the Four Masters*, gold-placers were worked in the valley of the Liffey and probably in the head-waters of the Slaney.† The western portion of county Wicklow and eastern Kildare have not been explored since the "time of the old men:" the more recent workings having been in the Woodenbridge district of eastern Wicklow.

In connection with a "gold-digging" or "streaming" there are the quartz-reefs, the shallow placers, the deep placers, dry-gulch placers and shelf or bar-placers. In the eastern Wicklow diggings, reefs have been unsuccessfully looked for. The gold was principally worked in shallow placers; and in a few places in the dry-gulch placers; but in modern times neither the deep nor the bar-placers have been explored.

The future of gold-mining in Ireland was very exhaustively entered into by the late Mr. Gerrard A. Kinahan in his paper on "The Mode of Occurrence and Winning of Gold in Ireland,"‡ and by the writer in his papers on "The Gold and Placer-mines of Wicklow,"§ and on "The Possibility of Gold being found in Quantity in County Wicklow."‖

Iron.—In prehistoric times, iron was probably known and worked, but the records of the implements made are now very sparse, as iron rusts or decays away so fast if buried. Rods of

* *O'Curry Lectures*, vol. iii., page 205.

† *Economic Geology of Ireland*, 1889, page 10.

‡ *Scientific Proceedings of the Royal Dublin Society*," new series, 1882, vol. iii., page 263.

§ *Quarterly Journal of Science*, 1878, vol. xv., pages 189-194.

‖ *Scientific Proceedings of the Royal Dublin Society*, new series, 1883, vol. iv., page 39.

peroxide of iron have, however, been found in some of the crannôgs, which probably are the last remains of buried implements.

One of the earliest authentic records of the smelting of Irish iron-ore and its manufacture, seems to be that left by — Chichester (1609); who states in his report that on arriving in the country he found that the native smiths were smelting the ore in small bloomeries and manufacturing it into steel far superior to the English. During the troubled times, the Irish and the Anglo-Norman producers, whose old bloomeries and works are to be found in various places, seem to have died out; and the great boom in iron did not occur until after the English and Scotch settlers had taken up their abode in the country about 1600, the remains of their furnaces and other work being conspicuous.*

Dr. Gerrard Boate's *Ireland's Natural History*, chapter xvi., is descriptive "Of the Mines in Ireland, and in particular of the iron-mines." † This author says that some of Giraldus Cambrensis' statements are evidently untrue and fictitious and are due to his credulity; and we may say the same of the records left by Dr. Boate. Nevertheless, there is in places valuable information to be gleaned from it, such as his description of the iron-mines and works. From him we learn that there were three sorts of iron-mines:—(1) bog-mine, (2) rock-mine (hæmatite), and (3) clay-ironstone called by several names.‡ Of these the bog-ore is the richest, but, on account of its friable nature, in the melting it must be mingled with some of the other sorts. The rock-mine or ore, if melted by itself yields "very brittle iron," so that nearly invariably it was mixed with bog-ore. The clay-ironstone was of very different qualities, some being much richer than others.

The bog iron-ore nowadays does not seem to be exported or in any way used for smelting, although on account of its easy and cheap winning, it ought to be valuable to mix with some of the English ores.

Partly allied with the bog iron-ore, are the aluminous ores of county Antrim, of late years more or less extensively worked. This subject has been considered in Mr. Philip Argall's "Notes

* *Economic Geology of Ireland*, 1889, pages 63-64.

† Page 122. ‡ Page 125.

on the Tertiary Iron-ore Measures, Glenariff Valley, County Antrim,"* and in a paper by the writer on "The Iron-ore Measures of County Antrim."† In the latter, it is pointed out that these iron-ore measures for the most part appear to have been lacustrine deposits, which accumulated in shallow boggy lakes or ponds, in hollows on the ancient surface of the sheets of Eocene dolerites as found at the present time in the United States of America; and they were subsequently covered by the newer Miocene flows. At a later period, the lacustrine accumulation contracted, and dried away from the roof, and in the space thus formed the veins of pisolitic or pebble-ore were secreted. Some of these Ulster accumulations, however, were not on this geological horizon.

The Kainozoic iron-ore trade is of recent development. In 1609, — Chichester mentioned this ore, and in 1683 Dobbs suggested that it existed in Island Magee. An Earl of Antrim also considered that the ore had a future value, and when he sold his property he reserved the mining rights. Its value, however, was not generally known before 1861, when Dr. Ritchie specially directed attention to these ores—afterwards they were successfully worked until the depression in the iron-trade. The occurrence of the pisolitic ore is peculiar, for although it appears as if bedded, its genesis was evidently long subsequent to the formation of the associated rocks and ores.

Associated with the iron-ore measures is the alumite or alum-clay. This has been very profitably worked. It is allied to the French bauxite (with which it has been erroneously classed) and to the German wocheinite; but the typical alumite is superior to both the French and German clays. In the Irish mineral the alumina is the hydrated variety. In the others the alumina is both hydrated and anhydrous, and in all the known processes of alum-making the sulphuric acid only extracts the hydrated alumina, therefore, in the Continental minerals there is a loss of from 6 to 8 per cent.‡ The alumite is always associated with lignite; while where there is no lignite we find bole, a ferriferous clay very similar to Continental bauxite and wocheinite; it may

* *Scientific Proceedings of the Royal Dublin Society*, 1881, new series, vol. iii., pages 151 *et seq.*

† *Transactions of the Manchester Geological Society*, 1893, vol. xxii., page 458 *et seq.*

‡ *Economic Geology of Ireland*, 1889, pages 65 to 67.

therefore be suggested that the alumite is bole out of which the iron has been leached.

About thirty years ago, an extensive export trade in bog iron-ore, principally from county Donegal, sprang up: the stuff being required in a process for the purifying of coal-gas.* The raw product in itself was of little value; but after it had taken up the gas impurities, the "gas-waste" was so valuable that the exporters found it profitable to supply the ore free of cost, on condition that the "gas-waste" was returned to them. Mr. W. E. Adeney states "after it has been used for the purification of the gas, the ammonium salts are first extracted from the spent ore by means of water, the fine ferriferous powder deposited being very valuable in the manufacture of brown-paint. The residue then is dried and burnt for sulphuric-acid manufacture. The cinder left after burning off the sulphur can be sent back to be reused for washing gas." The export trade was of very short duration, as when it was found that the cinder was capable of being used over again only a very small quantity of the raw material was required to make up for the deficiency in the quantity due to the waste, while the impurities are being extracted. The trade ceased so suddenly, about fifteen years ago, that a quantity of the stuff ready raised for exportation, is now lying on the Donegal hills. In places on the Donegal quartzite-areas, there is a peculiar buff-coloured variety, an earthy chalybite. This, while the ore was being exported, was found to be more suitable for gas-purification than the ordinary ore; but it had to be raised and allowed to weather for a year, to allow the carbonate time to charge into the peroxide. Special attention may be called to this ore, as it ought to be valuable as an addition in the manufacture of iron from some of the English and other ores.

A curious statement was recently made at a meeting in Cork, over which Sir Horace Plunkett presided: his subordinate mentioned as a triumph for his department, that they had discovered bog iron-ore in the county of Cork.† The discovery, however, was rather stale, considering that this ore was one of those smelted by the Earl of Cork in 1600. The lecturer evidently was rather innocent of his subject, but the statement

* It should be mentioned that the bog iron-ore may be hydrous or anhydrous. The latter is useless for gas purification; but Mr, Ritchie of Belfast had invented a process by which the anhydrous was changed into the hydrous variety.

† *Cork Constitution*, October 23rd, 1902.

being countenanced by Sir Horace Plunkett was rather pernicious, as already it has been quoted, and owners of at present nearly valueless ore have been led to believe they have valuable properties.

As to the ore in veins mentioned by Dr. Boate, most of the old workings are unknown and very little has been done with this class of ore since the Irish furnaces were extinguished. Now and again some of it has been raised and a little export trade began, but never to last any time. The ore is rather peculiar as rarely is it a red hæmatite, but usually an admixture of brown and red hæmatite; and, as pointed out by Dr. Boate, more or less siliceous.

Of clay-ironstone, there seems to be a nearly inexhaustible supply; as on one horizon in the Lower Coal-measure shales a little below the Earl's Hill or First Coal-seam, it occurs abundantly. These beds in various places were worked along their bassets by the iron-masters, and the ore-seams were so plentiful that rarely do the miners seem to have gone to any considerable depth.

Of late years, different attempts have been made in a few places to run a smelting trade with peat-fuel, especially in the Connaught coal-field, but none of the adventures have been crowned with success. Some of the beds are excessively rich, but a want of an economical fuel has been the great stumbling block. The Irish mineral coal is not suitable or plentiful enough for smelting purposes, while as yet no economic mode of working with the peat has been perfected.

Silver.—Silver, it is evident, was comparatively plentiful in olden times, as there are records in different places of numerous silver-mines. The ore usually worked was more or less argentiferous galenite; but some native silver was found in minor quantity.*

Dr. Boate† states that three silver-mines were discovered by the English. He mentions a mine in Antrim that gave 1 pound of silver to 30 pounds of lead; a mine on Coney Island in the estuary of the Sligo river, and Silvermines in the county Tipperary. The first two mines are now unrecorded and seem

* *Economic Geology of Ireland*, 1889, pages 11 and 12.

† *Ireland's Natural History*, 1652, page 141.

never since to have been worked. The locality of the Antrim mine is quite unknown, but Coney Island might be worth exploration. From the *Annals of the Four Masters* and other sources, however, we learn that mines in olden times were worked at Tulla, county Clare; at Carhoon, near Tynan, county Galway; and Ballygallion, near Inistioge, county Kilkenny (this is supposed to be the Argetros (*silverwood*) of the *Annals of the Four Masters* where silver shields were made, A. M. 3817); Garrane, near Toomavara, county Tipperary (this is supposed to be Rosargid (*silverwood*) of the *Annals of the Four Masters*); and Connary, county Wicklow, where stone and other rude mining implements were found.

Silvermines, county Tipperary, is said by Dr. Boate to have been discovered by the English; but the researches made during the last century and statements in the *Annals of the Four Masters* would suggest that it had been previously worked by the Irish. When the mines were destroyed by the O'Kennedy's in 1641 they were being worked by Dutch and English miners.* The Silvermines mineral channel is interesting, being a contact-lode at or near the junction of the Carboniferous and Ordovician rocks, but subsequently more or less faulted. It extends for at least 30 miles, from Gallow's Hill, county Clare, on the westward, to Toomavara on the eastward. Along this line, old mines were worked at the previously mentioned Garrane and at Silvermines; while in the western extension, county Clare, the ground is as yet untried, although there are good indications, which would suggest that in other places along this contact break, profitable lodes may yet be discovered. The Silvermines, since 1600, have been worked by different English adventurers.† Here there are some complicated faults.‡ Dr. Boate states that the ores worked here were one "of a reddish colour, hard and glistering [evidently blende]; the other is like a marle, something blewish, and more soft than the red [galenite]; and this was counted the best, producing most silver, whereas the other, or glistering sort, was very barren."§ It would appear that the

* *Ireland's Natural History*, 1652, page 144.

† *Economic Geology of Ireland*, 1889, page 100.

‡ *Memoirs of the Geological Survey of Ireland, Explanations to accompany Sheet* 134, pages 31 to 41.

§ *Ireland's Natural History*, 1652, page 142.

blende was run into the old workings, where it decomposed and changed its original character; as about 1858 in the ochreous gossan found in the old men's working, near the Mining Company offices, a whitish nearly transparent crystalline mineral was observed, occurring in veins, pipes and hollow concretions or scattered through the gossan, which Dr. Apjohn pronounced to be electric calamine or silicate of zinc. With this was found a little of the carbonates and sulphides.

According to the report of H.M. inspector of mines, 1902, just published, explorations are now being made "and a quantity of calamine, copper-pyrites and lead-ore have been obtained, all being still in stock at the mine."* The state of the mines in 1861 was recorded in Mr. A. B. Wynne's report.† It might be profitable to explore some of the other ancient silver and lead-mines, for elsewhere, as a general rule, the ancient mines that in modern times have been explored, have been found more or less profitable.

Copper.—Copper must have been well known by the early inhabitants, if we are to judge by the innumerable bronze and copper-implements that are continually being found; yet so far as the writer has as yet learned, no mention of ancient copper-mines are found in the *Annals of the Four Masters.* However, in different places in course of mining operations during the last century, "old men's workings" have been found. In county Tipperary, ancient workings for copper-ore exist at Gortnahalla, near Borrisoleigh; at Lackamore near Newport, ancient tools were exhumed in the "old men's workings"; and also at Ballycohen or Hollyford near Cappawhite. In county Kerry, at Muckross, and Ross Island, Killarney, are very ancient mines, recorded by Nennius, a ninth century writer, who mentions copper, lead, tin and iron. Smith, in his *Natural History of Kerry*, states that he found ore containing tin near the lake; but in subsequent records no mention of it is made. When working the copper-mine at Muckross in 1794, Mr. Raspe discovered cobalt-bloom and grey cobalt. After the discovery little remained to be utilized, as all the accumulation except about 20 tons had been run into the lake as rubbish. The

* *Report on the Inspection of Mines and Quarries in the Manchester and Ireland District, 1902*, by Mr. John Gerrard, page 34.

† *Memoirs of the Geological Survey of Ireland, Explanations to accompany Sheet* 134, pages 31 to 42.

small portion saved had been surreptitiously carried away by a miner who recognized it as erythrine or arseniate of cobalt.*

At the Stage lode, Knockmahon, county Waterford, in "old men's workings" were found rude stone and wooden implements. In this lode, there were also silver, lead, zinc and cobalt. In the Ovoca mineral channel, county Wicklow, in places there seem to have been very old workings, but possibly these were for lead.

In west Cork are Devonian rocks, called on the Geological Survey maps "Lower Old Red Sandstone" and "Upper or Yellow Sandstone." The latter contain many metalliferous beds in which the ore is principally grey copper-ore (tetrahedrite) the backs of the beds weathering into the carbonate or the black oxide. In some places, certain rocks in the summer months become a greenish-blue from the tetrahedrite weathering into carbonate, but in the winter-rains these rocks are washed quite clean; where does the copper go to? A rather extraordinary statement has been made by one of Sir Horace Plunkett's experts in a work called *Ireland: Industrial and Agricultural*, 1902. This is to the effect that in Ireland the tetrahedrite has been erroneously mistaken for copper-glance (redruthite); now the latter mineral is a rare Irish ore, as it has only been detected in a few localities, while in south-west Cork, the most prevailing minerals are the grey ores, tetrahedrites (argentiferous and possibly auriferous) occurring both in the beds and lodes.

The Upper or Yellow Sandstone is the productive zone in south-west Cork. It has been found that although the quartz-lodes traverse both the upper and lower, yet the moment they pass the limits and penetrate into the Lower Old Red Sandstone, they are barren. This is very conspicuous in the Bearhaven or Allihies mines, as the champion quartz-lode occurs in both groups, but was found to be quite unfertile when the boundary was crossed. The ore was first noted in a great quartz-ramp running as a small promontory into the sea at Allihies. To the eastward this quartz-lode becomes a horse, a siliceous breccia made up of fragments of the country-rock; further east, in the Mountain mine there were, at grass, two quartz-lodes more or less profitable, that in depth joined, to be again separated by a horse of country-rock before they became unprofitable. To the

* Sir R. Kane.

eastward the Mountain mine is cut off by a cross-course and at the latter there was a large pocket of the carbonate and oxide, said, undressed, to return 90 units of copper.

While these mines were in "riches," numerous shafts were sunk on all the different quartz-lodes in the Lower Old Red Sandstone with unsatisfactory results. The Mountain and north and south lodes became unprofitable, and the mines were eventually abandoned. The late Sir Warington Smyth stated, in connection with the Mountain mine, that at 900 feet "the chief point of note about the lode here was, however, that from its hardness and moderate admixture of ore, it would have been, if small, unprofitable, whilst from its great size, allowing of operations on a large scale, it proved highly remunerative."*

It may be suggested, as the Mountain and other mines have now for many years been flooded, that the mine-water must be more or less impregnated with copper, and that the water might be pumped out, and the copper profitably precipitated therefrom.

In south-west Cork, to the southward and south-east of Bantry Bay, there are some mining setts which ought to be remunerative, and there are the metalliferous beds that were formerly not very profitable; but now, on account of modern methods, they may be worth working. Possibly in them, the ore might be concentrated by a magnetic process; or after the stuff was ground and the ore separated by steeping, puddling and washing, the copper might be won from the water by the cementation-process already mentioned.

At Kilcrohane (Sheep Head) mine, the copper-ore is auriferous; also at Carrigacat or Dhurode. The last named are said to be very ancient. Copper-ore from Ballycummisk has been proved to be auriferous by a recent analysis. At Derrycarhoon, near Ballydehob, a very ancient working was discovered by Mr. Charles Thomas. The excavation was 60 feet long by 60 feet deep and 4 feet wide between well defined walls. All the stuff in the working had been removed by the "old men," as not a trace of it remained. Wooden and stone implements, a curved tube of oak, and a primitive ladder, an oaken pole with rude steps cut in its sides, were found in the old workings. All traces of this ancient working were obliterated by a surface-growth of peat over 14 feet thick: this may represent a period of 3,000 years or more.

* *Memoirs of the Geological Survey of Ireland, Explanations to accompany Sheets* 197, etc., pages 30-32.

In county Tyrone, there is another tract of Devonian rocks. Here, at the mearing between the Pomeroy and Carrickmore manors, are metalliferous quartz-lodes. This district may be considered a virgin one, as except in the vicinity of the Dungannon water-works, where there were some shallow trials on a coppery lode, no explorations have been made. This is one of the two places where copper-glance (redruthite) is recorded as having been found in Ireland. The lodes at the Pomeroy and Carrickmore mearing seem worthy of research, more especially as the exploration ought not to be expensive.*

The Bonmahon or Knockmahon mines, county Waterford, were worked in prehistoric times; as shown in the "old men's workings," at the Stage lode, where rude stone and wooden implements were found. In this lode, besides the copper there was also silver-lead, zinc and cobalt. These mines have had a very varying record. From the time of Queen Elizabeth down to 1730, some of the lodes at intervals, appear to have been worked; at the latter date they were in the hands of Mr. Hume, who for some years worked the Stage lode very successfully. Next we hear of Col. Hall and Mr. Galway, who spent a large sum unsuccessfully. In 1796 the mines passed to the Hibernia Mining Company. The mine was acquired, in 1824, by the Mining Company of Ireland, who until 1876, carried on mining with varying success; and about 1880 the works were abandoned, as the lodes had become unprofitable. The future of these mines is obscure, as there seems no hope for them; but it must be remembered that after many failures the net profit in 1862 was £20,000.†

The mineral-range is county Wicklow on which the Ovoca mines are situated, is possibly at present the most important undeveloped mineral ground in Ireland.‡ This range extends from the Deputy's Pass southward of Wicklow town, all but continuously in a southward direction to the Ovoca river, and from there to the flanks of Croaghan-Kinshella, in all a distance of about 15 miles. To the eastward, in the range, the lodes are ordinary lodes in the country-rock; but in the East and West

* *Economic Geology of Ireland*, 1889, page 33.

† *Memoirs of the Geological Survey of Ireland, Explanations to accompany Sheet* 168, page 81.

‡ *Economic Geology of Ireland*, 1889, pages 108-119.

Ovoca mines, there is a peculiar wedge-shaped channel in the country-rock, in which there are one or two main lodes. This channel was formerly supposed to run with the strike and dip of the country-rock "but recent research has shown that although the general direction of the lodes, may be more or less with the strike of the 'country-rocks,' yet the channel and lodes always cross the latter, although sometimes at a very small angle, while in depth both dip at a greater angle than the 'country-rocks.'"* This channel is conspicuous in the mining setts, east and west of the Ovoca river, but it does not occur to the eastward in the Ballycapple setts, or westward in those of South-west Ovoca or Knocknamohill, or in the Carysfort mines to the south of the Darragh water. In the country-rock north of the East and West Ovoca setts, there is a north lode. This, it may be suggested, is the lode to the eastward in Ballycapple and one of the lodes to the south-westward in the Knocknamohill and Carysfort mining sett. Possibly, against such a supposition, it may be pointed out that in the Knocknamohill sett there are two well-marked lodes and in those of Carysfort there are three.

Beginning to the eastward. In the country east of the fault of the Deputy's Pass, no lode is recorded. West of this fault in the Ballycapple setts, townlands of Ballycapple and Ballard, the iron-back of the lode was worked by Messrs. Chamney of Shillelagh, the ore being superior, a mixture of magnetite and hæmatite ores. The lode was never worked, but from fragments in the attals of a trial on it, it seemed to be a coppery pyrites.

The range between Ballycapple and Kilmacoo, in a south-west line of about 3 miles, is very little known. In the townland of Rockfield, 1 mile north-north-east of Kilmacoo is an assembly of "shode-stones" very like those of the Ovoca channel.

The fault, a little east of Kilmacoo or Connary cross-roads, cuts off on the east the Ovoca channel. In this channel, between this fault and the Ovoca river, lie the East Ovoca mines in two groups:—To the north-eastward, there are Kilmacoo, Connary and the Magpie or East Cronebane; and to the south-westward, West Cronebane and Tigroney. These deposits are very exhaustively described in Mr. P. H. Argall's memoir† and by the present writer.‡

* *Economic Geology of Ireland*, 1889, page 113.

† "Notes on the Ancient and Recent Mining Operations in the East Ovoca District," *Scientific Proceedings of the Royal Dublin Society*, new series, 1880, vol. ii., page 211.

‡ *Economic Geology of Ireland*, 1889, page 113.

There are, however, special features of interest in the Kilmacoo, Connary and Magpie setts; there being more or less considerable quantities of that peculiar ore kilmacooite or bluestone. This mineral seems to be an admixture of the sulphides of zinc, lead, iron, copper, antimony, arsenic and silver, with a trace of gold; it varies, however, in its composition. Up to the present time, no economical process has been found by which to disentangle the different ores. It has, however, been suggested that this could be done by magnetic separation, but as yet the experiments are not completed.

To the westward of the Magpie mine, between it and the West Cronebane mine is the tract called the "Yellow Bottoms," an area occupied by a surface-field of ochre; this during explorations made in 1879 and 1880 was proved to obscure a massive sulphur-ore lode (coppery pyrites). The Yellow Bottoms was rather a puzzle, as evidently it had been honeycombed by numerous pits. The latter have been explained by recent explorations, as now it is known that under the ochre there was a "gossan-lode" of black auriferous copper-ore, and this was won by the "old men" on the same principle that placer-mines for gold are worked at the present day.

The ores in the channel-lodes, to the east of the Yellow Bottoms are different from those on the west. In this division, there are two main lodes in the channel, both are wedge-shaped. The walls closing in depth on account of the hanging or south wall, standing more perpendicular than the foot or north wall —some of the sulphur-ore in the north lode still remains, though not much, as it has been bottomed in places; but in the deepest working, at the William shaft, the walls again appear to be opening. In the Magpie shaft, the lode in depth is cut out by a granite-protrusion or intrusion.

Tin.—Tin-ore must occur *in situ* somewhere in the Ovoca district, on account of the quantity found in "the streaming" for gold in the Goldmine valley; it may, therefore, be suggested as a possibility, that, as in Cornwall when the copper in the lodes die out (especially if in granite) at a greater depth, tin-ore may replace the copper-ore; here, therefore, in the Ovoca mines the same thing may take place. Tin-ore in the streaming and not as yet found *in situ* is hard to explain.

The granite of Croaghan-Kinshella is the young granite probably of the same age as the Dartmoor or young granite (Devonian) of Cornwall. This may account for the tin-ore in Cornwall and Wicklow; but the latter is a puzzle.

The prehistoric Irish were extensive workers in bronze, as is proved by the numerous implements and other relics found scattered over the county. Dr. P. W. Joyce points out that *aerarius* is equivalent to *cerd*, the first literally signifying a worker in brass (possibly bronze); also that Ballynagard (Irish: *Baile-na-gceard*), the town of the artificers or brass-workers is not an uncommon place-name in Ireland. Besides there are the old habitations, raths and such like, in which are found crucibles, moulds, and other implements of their trade. Brass at the present day is an alloy of copper and zinc, while bronze is the alloy of copper and tin; these ancient Irish implements may be of copper, but most of them are of bronze (tin and copper) and rarely if ever, of modern brass (zinc and copper), as we are informed by Dr. George Coffey, keeper of the collection of antiquities of the Royal Irish Academy. It therefore becomes a question: Where did the ancient Irish get their tin? Another is: Why did they not utilize zinc which they had in abundance? It should be mentioned that lead is found in some of the later ancient "bronzes," also traces of iron.

At the present day, the following are the only recorded localities for tin:—Dalkey, county Dublin, and the Goldmine valley, county Wicklow. Nevertheless, some of the old historians mention it as having been found near the Lakes of Killarney, county Kerry.* There is a vague rumour that it has also been found in the copper-mine at Kilcrohane (Sheep Head), county Cork.

An area that probably has a future is that of the metamorphic and granitic rocks, west of Lough Corrib, county Galway or the Oughterard district. Here there are many lodes and indications of copper, sulphur-ores (pyrite and pyrrhotite), lead and zinc, some rich bunches having already been extracted. All the mining operations have been on a small scale, proving the lodes at the surface, but not in depth.

* *Natural History of Kerry*, by — Smith, and *Economic Geology of Ireland*, 1889, page 11.

Salt.—Irish minerals that seem to be kept very much in the background are salt, and steatite, with its relative pyrophyllite.

Possibly the only salt-measures are those in the Trias of county Antrim. They have been proved to exist from Eden on Belfast Lough northward to Larne; yet they have only been utilized at Duncrue. Here the salt-measures are from 100 to 160 feet thick. In the old pit, there were over 100 feet of salt, 13 feet being rock-salt, the rest of the thickness being impure. In other portions of the area, bore-holes or pits might be put down, and by them the salt-measures flooded, thus causing lixiviation and generating a lye, which should be pumped up and evaporated to produce lixivial salt. According to Prof. Dana,* at the principal salt-springs in the United States of America, the amount of brine or lye required for a bushel of salt varies from 30 to 450 gallons; while it takes, in accordance with the quality of the beds from which the salt is lixiviated, from a month to twelve months in the Austrian mines to saturate the water. In Antrim, there ought to be facilities for working, as the pits or bore-holes could be flooded with sea-water and thus hasten the saturation. Sea-water ought to give a bushel of salt from 200 to 300 gallons, but the result must vary greatly, as some waters are more saline than others. Very poor water ought to be remunerative, as the American wells at Boone's Lick, Missouri, require 450 gallons for 1 bushel of salt. It would, therefore, appear, if the salt-measures were worked by the lixiviation method, that the adventure would be remunerative.

Formerly, salt-works and pans for the manufacture of salt from sea-water were to be met with in various places on the Irish coast. Some of the works, like those at Slade, Hook Head, county Wexford, were very extensive. Others had large shallow troughs or pans cut in sheets of rock for aërial evaporation, like those at Salt Hill, county Dublin, which were in existence till after the Kingstown railway was made; or like those at the salt-pans on the shore of Lough Swilly, county Donegal, where there were large metal boilers in which the lye was boiled. These works on Lough Swilly were in existence till all the peat in the vicinity was exhausted, the boilers being *in situ* a few years ago. Here the old tenant stated that rock-salt

* *Manual of Mineralogy*, 1871, page 106.

used to be imported and stewed down with the sea-water lye. The only survivors of these old works still in existence are those of Messrs. Flower and McDonald at Balbriggan, county Dublin, where superior salt for all purposes is manufactured. Here they add to the sea-water lye rock-salt from Duncrue, county Antrim.

Steatite.—The hydrous silicate of magnesia, steatite, occurs in mass on the islands of Bofin and Shark, off the coast of Galway, but belonging to county Mayo. There are pseudomorphs after dolerite. A portion of the mass on Bofin island is of a very superior quality. In Claggan, Achill island, county Mayo, there is an irregular bunch or pocket-vein, in part crystalline and very pure.

In county Donegal, in various places, there is pyrophyllite, the hydrous silicate of alumina. A bed (?) of this, at Carrowtrasna, was for some time worked profitably and sent into the market as steatite and used as a lubricator. At Crohy Head, there is a vein or bed said to be steatite.

Rocks of the saponaceous class are recorded in the counties of Antrim, Cork, Donegal, Galway, Mayo and Wicklow. These minerals may occur in many other places, as they have not been carefully looked for. In county Donegal, the compact variety, or camstone, is recorded. This formerly was much used for architectural purposes.

Fullers' Earth.—Beds of steatitic clay or fullers' earth are found in different places, and formerly were much used for abstracting grease from woollen articles, while in county Galway they are still used for that purpose.

Pyrophyllite.—Pyrophyllite has been used in the manufacture of lubricators and as packing for pistons in machinery. It contains 30 units of alumina and may possibly, therefore, be utilized in the manufacture of alum and aluminium. Steatite nearly invariably occurs as a subordinate adjunct of the intrusive rocks forming veins and masses of more or less pure silicate of magnesia. In county Donegal the pyrophyllite seems to occur in beds as if it were a methylotic sedimentary tuffose rock. The weathered back is a friable saponaceous substance.

Molybdenite.—Of late, in the manufacture of steel, experiments have been made with molybdenum. As yet they seem to be unsuccessful, but at any time there may be a demand for this metal; it may be mentioned, therefore, that molybdenite (the sulphide) and molybdite (the oxide) occur in quantities in a massive granitoid ramp that comes up through an intrude of black granite (Tertiary) at Murvey, a few miles west of Roundstone, county Galway. The ramp stands up above ground, as a wide course; if, therefore, there arose a demand for the ores, the winning would be at a minimum cost, as all that would be required would be ordinary quarrying.

Mr. J. Holms Pollok, B.Sc., F.C.S. (Dublin) wrote that Mr. Kinahan's interesting paper was certain of an enthusiastic welcome from those interested in the development of the metallurgical, mineral and mining interests of Ireland. And for that purpose, it was necessary not only that the history of mining and metallurgy in that country should be kept alive, but that an interest should be awakened in metallurgical chemistry and mineral analysis in the various colleges in Ireland.

He regretted that Mr. Kinahan should lay such stress upon the occurrence of gold in Ireland. No one had ever found a single stringer of quartz that assayed 1 ounce per ton or a large reef that assayed 2½ pennyweights per ton. He (Mr. Pollok) had found little stringers of quartz, all along the sides of Goldmine valley, that assayed ½ pennyweight per ton. In Howth, he had known of patches of quartz with 2 pennyweights per ton, and the same at Lambay, but these were absolutely valueless, and there was no reasonable prospect of payable gold being found in any part of Ireland. Of course, a few nuggets had been found, but the source of nuggets was difficult to explain in more countries than Ireland. The occurrence of gold in the beds of streams, was easily accounted for by ages of concentration from the exceedingly poor quartz in the adjoining country-rock.

It was in the direction of the examination and development of mines of iron, copper, lead, zinc, silver, coal, fire-clay, barytes, salt, kieselguhr, chalk, slate, marble, china-clay and the like, and possibly of molybdenum, cobalt and tin that one might reasonably look for a profitable return. To take coal, for

instance, it is known that there is coal in Ireland, but it is so full of pyrites as to be of little value. He suggested that an engineer should investigate the precise nature of the coal, the manner in which the pyrites is associated with it, and the best manner of separating it from the coal; but there was no possible inducement for anyone to do this, unless he were paid by the owners of the coal-mines.

The fact that the ancient Irish did not use zinc, in place of tin to alloy with copper, although they had the former metal in abundance, was easily explained, as the metallurgy of zinc was much more difficult than that of tin, and the method of reduction was not thoroughly understood by the ancients.

Colonel HUGH H. STEWART (London, S.W.) wrote that he was well acquainted with the district in county Tyrone, containing the tract of metamorphic and Devonian rocks, mentioned by Mr. Kinahan. Not being a geologist or mining engineer, he (Mr. Stewart) was unable to afford technical information, but the existence of mineral-deposits was evident even to untrained intelligence. Moreover, the number of spas, which Mr. Kinahan, on the occasion of an examination of the locality made about 12 years ago, declared to be strongly impregnated with copper, pointed to the probability of the existence of a lode of considerable magnitude, especially as the spas appeared to run in a regular chain on a north-west to south-east line. Some of these spas were remarkably strong, so much so that the inhabitants were unable to use the water for cooking purposes. The following paragraphs had been taken from a report upon this subject:—

(1) *Metamorphic and Granitic Rocks.*—On account of the large overbearing of drift and bog, none of the mineral-veins could be satisfactorily traced: no open-cuts were made; no costeeming pits or boring; the survey being solely confined to an examination of the spa-wells, but some of these hereafter mentioned may suggest the expediency of a more extended search, more especially as at the time (May) the spas were not at their full strength.

(2) *Metamorphic Rocks.*—In the townland of Altdrumman, immediately south-west of Lough Fingrean (County Tyrone, Ordnance sheet, No. 27) there are three coppery spas, and a little to the eastward in Lough Macrory, near Dermoot Grannia Bed, a strong chalybeate-spa. About 3 miles to the eastward, in Creggan, on an east-and-west line, are three coppery spas, which possibly indicate a coppery lode, as may also the coppery spas hereafter mentioned in the Devonian rocks. In the townland of Lough Macrory (Ordnance sheet, No. 36) south of the shooting-lodge, there are slightly coppery spas, and there are two spas of the same kind, 2½ miles to the south-east near Aghnagreggan Bridge.

(3) *Lower Devonian Rocks.*—Near the east mearing of the Carrickmore estate (Ordnance sheets, Nos. 37 and 45) there are numerous spas, as a general rule more or less coppery. A remarkable spa occurs on the boundary of Sluggan and Inishatieve, having the flavour of Harrogate water, and to the extreme north of Inishatieve there are also strong spas.

The chief means of preventing or killing mining industries in Ireland had been the policy of free imports, which had made it not worth while to develop the country or exploit or search for any latent ores or other products that involved any expense. Most of the large towns, being on the seaboard, access to them was more readily obtained from the Continent by sea than from the interior of Ireland by rail. Mining required a protective tariff and, that once obtained, many industries now dead or dying in Ireland would revive.

Prof. GRENVILLE A. J. COLE (Royal College of Science for Ireland, Dublin) wrote that the extraction of copper by placing iron objects in the water flowing from the mines had been, of course, performed in many countries, and was practised in Hungary in the seventeenth century. Mr. Kinahan did not refer to Mr. E. St. J. Lyburn's paper on "Prospecting for Gold in County Wicklow, and an Examination of Irish Rocks for Gold and Silver,"* which shows how the critical area in county Wicklow is not open to prospectors.

In view of the formation of pisolitic iron-ores in recent lakes, it seems improbable that the structure of the Kainozoic ores of Antrim is secondary, as suggested by Mr. Kinahan in his paper. The iron-ores, in fact, appear to have formed part of the lacustrine series of deposits. The bauxite in the same deposits is at present displaced by French bauxite as a source of aluminium, but it is still worked for alum. Attention may be directed to Mr. Thomas H. Holland's recent work in India on the connexion between bauxite and ferruginous deposits, such as laterite.†

He (Prof. Cole) believed that he was the "expert" referred to later as having stated "that in Ireland the tetrahedrite has been erroneously mistaken for copper-glance."‡ The state-

* *Scientific Proceedings of the Royal Dublin Society*, 1901, new series, vol. ix., page 422.

† *Geological Magazine*, 1903, vol. xl., page 59.

‡ *Trans. Inst. M.E.*, 1903, vol. xxvi., page 275.

ment made in *Ireland: Industrial and Agricultural, 1902*,* was that the reverse mistake in nomenclature had occurred; and he (Prof. Cole) believed that much, at least, of Mr. Kinahan's grey copper-ore would be found to be really copper-glance. Sir R. Kane† used "grey copper-ore" in this sense, and described it as "subsulphuret of copper."

Mr. H. J. Seymour‡ had added the Mourne mountains as a new locality for cassiterite in Ireland, the specimens being, however, merely minute crystals.

The present position of the salt-industry, near Kilroot and Carrickfergus, showed more activity than Mr. Kinahan had supposed.

The steatite referred to somewhat dubiously at Crohy Head is a massive talc-schist, and had been extensively excavated, but the works were, at present, closed.

Mr. E. Henry Davies (London) wrote that, in reading through the excellent paper by Mr. Kinahan on the subject of mining in Ireland, a matter on which he is one of the best authorities, he (Mr. Davies) was struck by the fact that he did not allude to the endeavours now being made to revive the mining industries of that country. Mr. Kinahan rightly referred to the successful mines of the past, and very properly indicated the points where, from his great experience, the mining operations of the future should be conducted.

One of Mr. Kinahan's suggestions based on the recollections of himself and of Mr. Philip Argall of Denver, U.S.A., was now being acted upon, and with results which amply confirm their anticipations. He referred to the exploration-works which have recently been undertaken by the Ovoca Copper Syndicate to locate and prove the existence of a large body of low-grade copper-ore, immediately under the alluvial covering at the Cronebane mines. This mass of ore, which at the time was completely invisible, was said to contain about 2½ per cent. of copper, and the recent exploration-works have proved that for a length of 700 feet, it has a width of about 50 feet and on a most careful sampling and assay of 5 tons, yields as an

* Page 20.

† *Industrial Resources of Ireland*, 1845, second edition, page 182.

‡ *Scientific Proceedings of the Royal Dublin Society*, 1903, vol. ix., page 583.

average 2·79 per cent. of copper, and contains gold and silver, in addition, to the value of 6s. per ton. This more than confirms the anticipated results; and, as the quantity seems to be inexhaustible, there is every prospect of this portion of the mineral-wealth of Ireland being worked to the profit of the old country, and also to that of the adventurers. In their researches after copper, an immense mass of white clay was found, and it promises to become a valuable part of their property. He (Mr. Davies) understood that the scheme included the unwatering of the Connary mines from the level of the railway, by means of a long adit-level, which should intersect all the lodes at a depth of some 700 feet below the surface, thus laying dry the Cronebane and Connary mines to that depth. It is proposed to extract a mixture of the two ores to the extent of 300 tons a day, and smelt them on the spot, as owing to the excess of sulphur in the one and of silica in the other, an ideal ore for pyritic smelting is thus obtained. In addition to the ores which they will obtain by mining they will also derive considerable profit by the precipitation of copper from the water, reputed to contain 40 grains of copper per gallon, flowing from the old workings.

Prof. J. P. O'Reilly (Dublin) wrote that the mineral statistics for the last available year furnish solid data for consideration and discussion. The total values of the ores, minerals and rocks raised in Ireland were £244,234 in 1901, and £235,053 in 1902. The principal items for 1902 are:—Igneous rocks, 222,121 tons, value £70,654; coal, 108,737 tons, value £53,197; and limestone, 446,243 tons, value £41,192; the total of these three being £165,043. And of the whole mineral products of Ireland raised in 1902, those produced by quarrying account for 50 per cent. of the total value, leaving but a small margin for the other individual minerals taken in detail. This practically measures the extent of mining in Ireland at the present time.

Mineral deposits exist in Ireland well worthy of further careful and skilled study, and many of them, if not all, are referred to by Mr. Kinahan. Wicklow is undoubtedly a mineral district well worthy of exploration and careful study. The mines were well worked and very productive, up to 1860 or 1870, in coppery pyrites. The Huelva-district minerals then drove these ores out of the

market, and practically closed the mines; a small production has since been maintained, and in 1902, 444 tons of this ore yielding 9 tons of metal are given with a value of £380. Nothing is said as regards precipitate copper, and yet the deposit is particularly favourable to the development of that form of copper-production. The old workings, containing backs of coppery pyrites, are very extensive, and still produce much copper-solution. As regards these mines, Sir Warington Smyth's work thereon, published among the series of the Royal School of Mines, is well worth reading. Mr. Cruise also gave a notice of them in the Memoirs of the Geological Survey, and Mr. Weaver's excellent report, although more than a hundred years old, is well worth examination and study. Much has been written and done as regards the occurrence of gold, but not enough by any means. There are so many districts of older crystalline and eruptive rocks in Ireland, particularly of diorites, and the amount of actual research and assaying is so small, that there is ground for thinking that gold may be found, in minute quantities it is true, in many rocks not now considered as being gold-bearing. He submitted a small contribution* in this way, done on his own account, and he had in hand results, in addition, of interest. As experienced miners knew, a great deal of ground had to be gone over, and many careful assays must be made before working results could be attained.

Mr. Kinahan refers to the pockets of galena which have been worked in the Carboniferous Limestone, more particularly in the Silvermines district, county Tipperary. Having been engaged in working the zinc-deposit there during the "sixties," he (Prof. O'Reilly) could speak of these mines from actual experience and knowledge. The lode with which the deposit is connected is one of the most remarkable in Ireland, both as regards the extent and the variety of ores which it has produced. Historically, economically and geologically, no more interesting mining district exists in Ireland; and he had no doubt that further search and development would lead to interesting discoveries. The zinc-ores are relatively poor, rarely having reached 45 per cent. of zinc, but the great difficulty and

* "Notes on Some Assays for Gold of Rocks occurring in the Neighbourhood of Dublin," *Scientific Proceedings of the Royal Dublin Society*, 1890, new series, vol. vi., page 450.

the essential impediment to the successful and continuous working of these mines was the heavy cost of carriage to market, mainly Swansea.

Some of the galena-deposits in the Carboniferous Limestone deserve attention, such as those which were formerly worked about Dublin, one of which at least remains in evidence to this day, that is, the vein that crosses the tram-line near the baths on the road to Dollymount. It is known that lead was wrought there, and that the works were drowned by the sea-water; and two old shafts, one on the shore, attest the fact. Other veins were found and worked quite near the city. It is almost certain that these veins form the fillings of main joints in the limestone, that they have pretty nearly the same general direction, and that if the known ones were carefully mapped and correlated with the systems of jointing known to exist in the district, lines could be laid down for further search; and, as they lie near the surface, such veins present favourable conditions for working.

The serpentine-deposits of the west are not mentioned by Mr. Kinahan, but they are worthy of examination at the present time. The rock, as such, is worked and shipped to the United States, where it is fashioned into *articles de vertu* and imported into Ireland, where it may be seen in many of our shops dealing in "knick-knacks." But mineralogically the rock presents another and very high point of interest, owing to the presence of minerals of the white metals, such as nickel, cobalt and platinum. The last-named was detected by Mr. William Mallet in the washings from the gold-bearing streams of Wicklow, and in the many analyses which he (Prof. O'Reilly) had made of the Bray Head rocks, nickel and frequently cobalt were found in determinable quantities. Mr. Edward Hardman, in one of his excellent reports, mentioned a hypersthenite of the serpentine-district, which contained from 2 to 2½ per cent. of nickel: a remarkable result, which would have led to further investigation had the fact been discovered in any other country of Europe. It is well established that the mother-rock of platinum is serpentine or hypersthene-rock; and yet, wide as the district of these rocks is in the west of Ireland, it has never occurred to anyone to examine the question, so important both scientifically and industrially at the present moment, by reason

of the many and increasing applications of platinum and the rarity of deposits of the metal.

There are many other questions arising out of Mr. Kinahan's paper, amongst others that affecting the most important "mineral" of Ireland, that is peat: a very vexed question no doubt, but worthy of the most attentive study.

Mr. G. H. KINAHAN, replying to the discussion, wrote that Irish coal was not included in his paper. He would, however, mention that it was a rather sweeping assertion to state that "it is so full of pyrites as to be of little value." The Leinster and Munster coals were indeed more or less infested with marcasite; still their market value, on account of their heating powers, was more than double that of Welsh anthracite. Unfortunately, however, the major portion of the profitable seams was exhausted.* The coals of the Connaught and Ulster fields could scarcely be called pyritous, some at least being classed as "sweet coals." It was very questionable whether it would be judicious for any colliery-owners to go to the expense suggested by Mr. Pollok.

The subject of gold in Ireland was very exhaustively dealt with in the papers previously mentioned; it was therefore unnecessary to go over old ground. It was remarkable that the neophytes in the study of mineralogy were so far behind the times; as they seemed to imagine that gold was only to be found in quartz-veins. In county Wicklow, one after another wasted their time with veins long since proved valueless. In this county, it was evident that the gold had some connection with the sulphur-ore lodes; which had been proved to be in some way related to the advent of the newer granite (Upper Devonian or Carboniferous); while colonial engineers who had visited the Goldmine valleys had suggested that the green tufaceous rocks possibly might also be worth examination. In county Wexford —as in county Cork, in the Transvaal, in Colorado, etc.—gold should not be as much looked for in the quartz-veins as elsewhere. In connection with Colorado, it might be mentioned that lately (1896) in the wild granite-hills of Cripple Creek, dykes of pitchstone had been discovered carrying at their margins that new and rare mineral calaverite, or telluride of gold. At the

* *Economic Geology of Ireland*, 1889, page 71 *et seq.*, and page 101 *et seq.*

present time, pitchstone had only been recorded in Ireland in the wild granite of Barnesmore, county Donegal; here therefore was a field to which young enthusiasts might turn their attention. Prof. O'Reilly had acted as pioneer in opening up another field for their research, having looked for and found gold in the basic igneous rocks. Prof. Cole did not seem to understand that every particle of gold in a royalty belonged to the tenant of the royalty; and that an unauthorised person who trespassed in covers, disturbing the game, for the purpose of appropriating gold or its ore, was very leniently treated, if he was only turned off the premises when he might have been handed over to the police and brought before a magistrate.

A specimen of chalcocite (copper-glance) from West Cork would be of interest. It seemed remarkable that two minerals so distinct in every way as this and tetrahedrite (grey copper-ore) should be confounded; and that such men as Messrs. Kane, Sullivan, Gage, W. W. Smyth and Wyley, and Cornish miners should have been mistaken. Sir Richard Kane called the mineral by the old nomenclature, subsulphuret of copper; if however, he had believed it to be copper-glance, he would have used the term sulphuret. A hand specimen of copper-glance, said to have been found in the Browhead mine, was exhibited as a great rarity, and it ought to be placed in the museum of the Royal College of Science, Stephen's Green.

The pisolitic iron-ore of Antrim was certainly of secondary formation, and the proofs that this ore was younger than the overlying roof of dolerite would be found in his paper on "The Iron-ore Measures of the County of Antrim."* In the same paper it was also shown that Irish alumite or alum-clay was distinct from ordinary French bauxite and German wocheinite. Irish bole, which was the first clay in Ireland worked for alum, was somewhat similar to bauxite, but yielded a better analysis. Bole was misnamed solely from the insane craze that had bitten young men to use foreign names, in place of those in use for years. This was the case with the bole—Mr. R. G. Norman, as the best authority on the subject, was asked what French alum-clay was called, and its name was immediately adopted. Similarly with the Bann clay, it was quite distinct in character

* *Transactions of the Manchester Geological Society*, 1893, vol. xxii., page 458 *et seq.*

and use from the German diatomaceous clay, yet this outlandish and incorrect German term was that given by an Irish Board in their *Guide to the Cork Exhibition.*

Irish lithomarge was identical with Indian laterite, if we might rely on the specimens sent to this country; in the variation in colour, in their structure and composition, and in the circumstance that both could be cut into bricks that hardened on exposure. The reports of Messrs. William King, Jun., and Robert Bruce Foote, of the Geological Survey of India, on laterite in India are found in their paper on "The Geological Structure of Portions of the Districts of Trichinopoly, Salem and South Arcot, Madras";* and further remarks on the same subject are contained in *A Manual of the Geology of India*,† by Dr. Val Ball. He (Mr. Kinahan) had stated that bright-coloured lithomarges were identical in aspect with some of the varieties of steatitic laterites collected by Mr. A. B. Wynne in Kutch, India."‡

The horizontal iron-ore lodes of county Antrim are of a similar character to the gossan-lode of a standing mineral-vein. In the latter case, the back of the lode, usually iron-ore, contracted away from the standing lode, and the gossan-lode accumulated in the vacancy. In the case of the Antrim lodes, the lithomarge contracted away from the roof leaving a space in which the ore was concentrated. These lodes are similar to standing ones, except that they are horizontal. It may be pointed out that lay-and-lay lodes or lodes between the beds of country-rock are often horizontal.

The serpentine mentioned by Prof. O'Reilly concerned the quarrying industry, and was therefore outside the limits of his (Mr. Kinahan's) paper. Members interested would find in the *Economic Geology of Ireland* lists and descriptions of all the recorded exposures of serpentine (both ophite and ophiolite). The saponaceous rocks, steatite and pyrophyllite, were however included, as they occurred in pockets, dykes and veins, and had in places to be mined. The accumulation at Crohy Head was specially mentioned, as it received the premier place in the *Guide to the Cork Exhibition*, although it was a mere bagatelle

* *Memoirs of the Geological Survey of India*, 1864, vol. iv., page 260.

† Part III., Economic Geology, 1881, page 549.

‡ *Manual of the Geology of Ireland*, 1878, page 163.

to others, such as the tract on Bofin Island, county Mayo; also because the mineral was peculiar in being for the most part laminated. He (Mr. Kinahan), in the *Economic Geology of Ireland*, had temporarily classed it as pyrophyllite, but others, including Prof. Dana, alleged that it was talc (steatite). The laminated variety of pyrophyllite was rather a stumbling-block; as it closely resembled talc in colour, feel, lustre and structure; but under the blow-pipe they acted quite differently, one being a silicate of alumina, and the other a silicate of magnesia.

In the interesting record by Mr. Davies of the exploration now in progress by the Ovoca Copper Syndicate, the "White Ground" was mentioned, but not the "Black or Coal Ground." The latter, however, might prove valuable to work as a bye-product, as Mr. Argall had proved that it contained an appreciable percentage of graphite. Mr. Davies appeared to regret that he (Mr. Kinahan) did not refer to the present endeavours to revive the mining industry. This, however, was a subject that ought to be approached cautiously, because, among other reasons, of free trade, which (as pointed out by Col. Stewart), had handicapped or bled to death Irish mining and most of the other natural Irish industries, including peat-cutting.

The PRESIDENT (Mr. W. O. Wood) moved a vote of thanks to Mr. Kinahan for his interesting paper, and trusted that it would draw attention to the industrial resources of Ireland.

Mr. T. E. FORSTER seconded the resolution, which was cordially approved.

Mr. T. E. PARRINGTON's paper on "The Adoption of a Balance-rope at Hylton Colliery" was read as follows:—

THE ADOPTION OF A BALANCE-ROPE AT HYLTON COLLIERY.

By T. E. PARRINGTON.

It is imperative, where winding has to be done from great depths, that some means should be employed to counteract the effect on the engine of the weight of the winding-ropes. To produce a large output, a high speed of winding is essential; and, to attain this with safety, the load on the engine must be as nearly constant as possible, throughout the run.

The method of applying a tail or balance-rope, hung beneath the cages, though in theory the most perfect, never appears to have come into great favour, especially in this district, owing no doubt to several admitted objections to its use; notably the increased strain on the sockets of the winding-ropes, on the cages, and upon the keps, when the cage is landed; and, in addition, the loop at the pit-bottom has frequently been a source of much trouble, probably owing to the want of some suitable means of guiding it.

The east pit, at Hylton colliery, is 20 feet in diameter, and is drawing coals from the Hutton seam at a depth of 1,560 feet. Some months ago, a balance-rope was introduced into this pit, and it has since been running, most successfully, beneath the cages, specially designed and built for its adoption. Each cage carries eight tubs, that is, four tubs on each deck: the intervening space, in which the men ride, adapts the cage to the double heapstead and obviates "decking." A draw-bar of forged iron, 2½ inches in diameter, runs through the cage from top to bottom. The cage is built in halves, and the draw-bar is inserted before the two sections are bolted together.

Fig. 1 (Plate VII.) represents the cage standing on the keps. At the lift, the draw-bar moves up until the collar, A, comes against the head of the cage, and the cage is taken off the keps and carried on the collar during the run, the draw-bar dropping again so soon as the cage is landed. By this means,

the extra strain occasioned by the weight of the balance-rope is never applied to the cage, while the keps are never required to carry more than the weight of the cage and its load, the balance-rope being always directly connected to the winding-rope by the draw-bar. In the event of the draw-bar falling until the collar, B, rests upon the cage-bottom, the principle would of course fail; but, unless the cage dropped very heavily upon the keps, this could never happen, the movement of the draw-bar being, at the extreme, about 2 inches in ordinary coal-drawing. The winding-ropes and balance-ropes are capped in the ordinary way, the sockets being rivetted and hooped (Fig. 1, Plate VII.). The winding-ropes, of Langs lay, built up of six strands of 17 wires each, are 5¼ inches in circumference and weigh 13·7 pounds per yard. In order to make the balance-rope as flexible as possible, special thin wire is used in making it, the full rope comprizing six strands of 37 wires each, and it weighs 12 pounds per yard.

Figs. 2 and 3 (Plate VII.) are a plan and a cross-section respectively of the pit-bottom below the dabbing-baulks; and they show how the loop, C, or return of the balance-rope is dealt with. The rope is made to run in a deep perpendicular groove, D, whose vertical sides guide the rope parallel to the bend, but in all other respects the course of the rope is entirely free. This method, the writer thinks, has not before been adopted in this district, although it has been in use for some years at collieries in South Wales, where he believes it was first introduced.

At Hylton colliery, the groove, D, is 22 feet deep and 2½ inches wide, and the sides are formed of redwood deals, 1½ inches thick. It will be noticed (Fig. 3) that the extreme bend, C, of the rope is allowed to project below the groove, this arrangement being found advisable in order to prevent the possibility of the rope becoming jammed. Owing to the twisting action of the balance-rope, the top deals of the groove, at first, wore through very quickly, but by substituting teak instead of redwood, at the top, the trouble has been overcome. This remedy is preferable to lining the top with sheet-iron, as is sometimes done: the noise in that case being very objectionable. In every other respect the arrangement has been found most satisfactory, and the extreme simplicity is a great recommendation.

Mr. T. E. Forster (Newcastle-upon-Tyne) believed that the first counterbalance-rope on this principle used in Northumberland was introduced at North Seaton colliery about 15 years ago, and it had been running ever since with most satisfactory results. The pit was 860 feet deep. An old-fashioned Murray winding-engine, before the counterbalance-rope was introduced, was raising about 850 tons per day; now as much as 1,300 tons was raised in the same time; and this was sufficient to show that a balance-rope would materially assist an engine rather light for its work. He was surprised that the system of balancing the load had not been more generally adopted in the North of England. At their collieries, 4 or 5 pits were now fitted with counterbalance-ropes: a trough at the pit-bottom was used, and a sheave, placed below the level of the flat-sheets, kept the rope tight. The cages were placed closer together than those described by Mr. Parrington in his paper. There was no arrangement for taking the weight of the cage off the keps, as they had never been used at the shaft-bottom at North Seaton colliery.

Mr. J. B. Atkinson (H.M. Inspector of Mines) said that at the deep pit, Newbattle colliery, and at two or three other pits in Scotland, the rope ran freely without passing round a sheave at the bottom of the pit.

At Kelty colliery, in Fife, where the pit was 1,224 feet deep, a singular accident occurred in connection with a balance-rope. A cage loaded with 4 empty tubs was leaving the surface, when the banksman was overpowered by an empty tub being placed in position to load the same cage in its next descent; and he was thrown into the cage, and the tub was jammed between the top ring of the cage and the flat sheets. The engineman had full steam on the engine to lift the cage at the bottom loaded with 4 full tubs and the movement of this cage tightened the balance-rope and applied power to the bottom of the cage at the surface sufficient to smash the tub holding it, and it eventually fell away. The rope had in the meantime got off the pulley, the distance it fell caused a jerk which broke the chains, and it fell to the bottom of the shaft. To avoid a similar accident in future, the timbers below which the balance-rope extended at the shaft-bottom were so arranged that they

e-rope at Hylton Colliery."

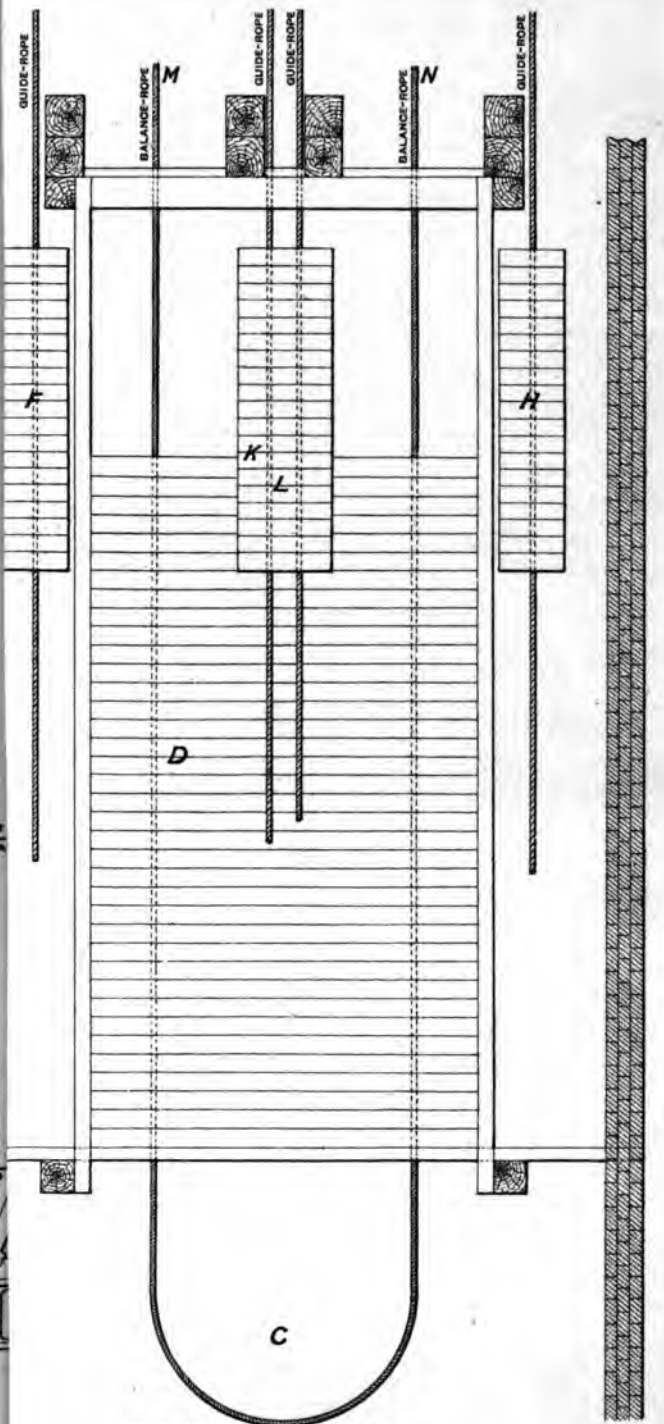


FIG. 3.—CROSS-SECTION.

would give way on a slight strain being applied. The winding-engine was worked without a balance-rope for a few weeks, and the output was decreased from 1,400 or 1,500 tons, to 1,000 tons per day.

Mr. W. C. Blackett (Sacriston) stated that he had adopted a similar arrangement for more than 15 years. At first, a chain was hung below the cage, and it gave great satisfaction, until a link of the chain was broken, but nothing serious happened when a chain fell into the shaft-bottom, as it fell dead. In recent years, a flexible rope had been used below the cage, and except on one or two occasions, it had given satisfaction. The rope was run in a deep groove at the shaft-bottom, and the loop was always free to move, if necessary. Many years ago, the subject of counterbalance-ropes was debated by Mr. John Daglish at Silksworth colliery, a very deep pit, and it was a grave question as to how a counterbalance-rope could be safely applied. The question received careful consideration, and it fell to his lot to design a rope tapering at each end from below the cages, so that it might afford an accurate counterbalancing load.

He noticed that, at Hylton colliery, the rope was socketed to the cage by rivets and hoops. Personally, he thought that rivets should never pass through a rope and socket; but there might be cases in which it was necessary. In his own practice, he had abandoned the use of hoops, and now used neither rivets nor hoops; the sockets were absolutely solid, carefully made, and accurately turned.*

Mr. Henry Lawrence (Newcastle-upon-Tyne) said that 45 years ago he applied the same method of counterbalancing to the cages connected with a blast-furnace hoist at Walker, after seeing it in operation at Middlesbrough. A chain was hung underneath each cage, and each chain coiled itself into the pit about a foot below the level of the ground; and it occurred to him that one chain would be sufficient, if it were run round a pulley at the bottom. The great point in this system of counterbalancing the weight of the load was to use a rope under the cage of the same weight as the hoisting rope, and then a perfect counterbalance would be obtained.

* *Trans. Inst. M.E.*, 1901, vol. xxiii., page 10.

Mr. A. L. Steavenson (Durham) remarked, as the counterbalance-rope weighed 12 pounds per yard and the winding-rope 13·7 pounds per yard, the winding-rope was only partially balanced, and the counterbalance-rope did not help the lift from the pit-bottom. He preferred to use a scroll-drum, so as to equalize the load on the winding-engine.

Mr. W. C. Blackett said that by the use of a balance-rope, tapered at each extremity, the same load-line could be obtained as with a scroll-drum.

Mr. John Morison (Cramlington) said that there was considerable novelty in the method of attachment of the cage, and of taking the load of the balance-rope off the keps. The arrangement of the groove for the return of the balance-rope at the pit-bottom might be novel, but he did not think that the groove was necessary, or that any means of guiding the rope was required.

About 9 years ago he had occasion to fit up the deep pit, to which Mr. Atkinson had referred, at Newbattle colliery. He adopted a balance-rope, and only a baulk was placed between the cages, in order that the loop of the rope might not become twisted. If a properly-made, flexible balance-rope was used, he thought that there was no need for any guiding arrangement at the pit-bottom. He could not see how Mr. Blackett's suggested method of using a tapered balance-rope would be better than an ordinary balance-rope.

Mr. W. C. Blackett said that it had been found necessary, at more than one colliery, to provide a smoothly-defined groove, or the equivalent of a groove, by a defined arrangement of timber. In his own experience, he had found that when the balance-rope was running clear, a kind of "gathering" took place, due to the centrifugal force in the return-loop, and eventually the rope was damaged. The balance-rope did not always run plumb, and the use of the groove was a decided improvement, and probably in many cases absolutely necessary.

It was true that with a balance-rope underneath the cages of the same weight as the winding-rope a perfect balance of the load was obtained, but Mr. Steavenson suggested that something more was necessary; and when the winding-engine began

to move, it wanted assistance in starting, just as when stopping it required resistance to bring it quickly to rest. This object was readily attained by using a balance-rope, with extra weight of rope under the cages, produced by tapering the extreme ends of the rope. Thus, when the empty cage was at bank, there was a greater weight of rope hanging underneath the cage than above, and it assisted the winding-engine to start. Also, as the loaded cage moved upward, a portion of the heavy end of the rope, below that cage, began to pass round the loop underneath the ascending cage; and, as it ascended, further portions of that tapered weight were added, until once more the rope was in exact balance during the middle of the winding. Then, as the ascending cage passed still further upward, the other weighted and tapered end began to pass round the loop at the bottom of the shaft and its influence was felt in a corresponding manner.

Mr. JOHN MORISON considered that the same object would be obtained by making the balance-rope a little heavier than the winding-rope.

Mr. J. H. MERIVALE said that he could not understand how the groove prevented the rope from jambing.

Mr. HENRY LAWRENCE said that he recommended the use of a floating pulley, with each of the spindles fitted into a solid bearing similar to the motion-bar of a horizontal engine, these moved up and down in parallel guides, with 5 or 6 feet of play up or down, and thus the rope was always kept in its place by the weight of the pulley.

Prof. HENRY LOUIS said that, so far as he was aware, the draw-bar arrangement of carrying the cage, described in the paper, was quite new. At a colliery in Westphalia, where the Kœpe system of winding was in use, the cage was hung within a bridle; but Mr. Parrington's arrangement was a somewhat different, and, as far as he could see, a better way of attaining the same result.

Mr. H. W. MIDDLETON said that a balance-rope had been in use for 6 or 7 years at Trimdon Grange colliery. At first an old winding-rope was used, but eventually that was taken

out, and a specially-made galvanized rope, weighing 23 pounds to the fathom, was adopted; while the winding-rope weighed only 17 pounds to the fathom. There was no special reason for using that particular weight, and the balance-rope would have been still heavier, if they could have made it so without providing a new winding-rope. The balance-rope had been running both free and with the rope turned round a pulley, and no difference in actual working was experienced.

Mr. J. G. Weeks, in moving a vote of thanks to Mr. Parrington for his paper, said that the writer had not assumed that there was anything new in the use of balance-ropes; but the novelty consisted in the use of a draw-bar, passing through the cage, and carrying the weight of the balance-rope hung below the cage, instead of throwing the strain upon the cage. He thought that the use of a heavier balance-rope than the winding-rope underneath the cages would be of assistance to the winding-engine; but with Mr. Blackett's system of thickening the extreme ends of the balance-rope so as to help the cage away, a deeper place would be required below the bottom of the pit, so that the rope should not be injured in bending and passing round the wheel.

Mr. W. C. Blackett, in seconding the vote of thanks, said that it was not essential that papers must contain novelties, for even old subjects, provided that they were of sufficient interest, could afford useful discussion.

The vote of thanks was cordially adopted.

THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE UNIVERSITY, BIRMINGHAM, OCTOBER 19TH, 1903.

MR. W. F. CLARK, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. C. FISHER, Coppice Colliery, Cannock, Walsall.
Mr. P. J. PERRY, Wolverhampton.
Mr. SHELFORD F. SOPWITH, Cannock Chase, Walsall.

STUDENT—

Mr. M. FRITZ SMITH, Mining Pupil, Hednesford.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1902-1903.

At the present time, there are 179 members of all classes upon the books, an increase of 8 members as compared with last year.

The Council regret to have to record the deaths of three prominent members, namely:—Mr. John Ashton, who joined the Institute at its initiation in 1867; Mr. W. J. Hayward, who joined in 1869, was President in 1880, and Treasurer for many years; and Mr. E. J. Bailey, who was elected in 1891.

The receipts have been more and the ordinary expenditure has been less. The Council have paid the whole of the arrears owing to The Institution of Mining Engineers: these have mostly been carried forward in previous balance-sheets, and have been caused by the late periods at which many members

have paid their subscriptions. Hence, the total amount paid to The Institution of Mining Engineers during the year has been £150 13s. 10d. This payment has necessitated a draft upon the bank-balance of £52 12s. 6d., leaving it at £209 3s. 7d. The arrears, unfortunately, are still large, amounting to £222 0s. 6d., although a special effort had been made by the Council to collect them, but the matter is still being dealt with.

Five General Meetings and 7 Council Meetings have been held, and several interesting papers have been read and animated discussions held. The President(Mr. T. J. Davies) contributed an exceptionally able Inaugural Address, which was poetically prophetic as to the mining of the future. Prof. R. A. S. Redmayne read a valuable paper on the "Training of a Mining Engineer," giving detailed information as to American methods, and a useful discussion followed. Mr. W. Best gave a demonstration and read a description of "A Magnetic Unlocking and Electrically-ignited Safety-lamp;" and Mr. F G. Meachem read a very interesting paper upon "Underground Temperatures," which elicited considerable discussion.

The Institution of Mining Engineers has made good progress during the last year, the membership having increased to 2,688. Meetings have been held in London and Newcastle-upon-Tyne. The *Transactions* embody 77 valuable papers on economics and science connected with coal and metalliferous mining, electricity, etc., and notes of papers from the *Transactions* of colonial and foreign societies and publications.

The Annual Meeting of The Institution of Mining Engineers will be held in Birmingham in September next, and the Association des Ingenieurs sortis de L'École de Liége will take part. The whole of the arrangements will be carried out by this Institute, and the Council hope that everything possible will be done by the members to make the visit a success, and to keep up the reputation earned on the previous occasions when meetings have been held in this district. The best thanks of the members are due, and are hereby tendered to the authorities of the Birmingham University for the use of rooms for meetings.

Dr. THE TREASURER IN ACCOUNT WITH THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1903. **Cr.**

	£	s.	d.		£	s.	d.
To Balance in Bank	261	16	1	By The Institution of Mining Engineers	150	13	10
„ Subscriptions received	176	18	6	„ Rent of Institute-room	20	0	0
„ Bank Interest	4	1	6	„ Salaries of Secretary and Reporter	50	0	0
				„ Expenses of Audit	1	3	6
				„ Printing and Stationery	7	5	6
				„ Postages	4	2	7
				„ Insurance	0	4	0
				„ Bank Charges...	0	3	1
				„ Balance in Bank	209	3	7
	£442	16	1		£442	16	1

BALANCE-SHEET, 1902-1903.

Liabilities.	£	s.	d	Assets.	£	s.	d.
To Balance	431	4	1	By Subscriptions due	222	0	6
				„ Balance in Bank	209	3	7
	£431	4	1		£431	4	1

Examined and found correct,

DANIEL ROGERS.
WILLIAM H. WHITEHOUSE.

October 19th, 1903.

This balance is exclusive of considerably more than £100 worth of property, for which no credit is taken.

The Annual Report of the Council and the accounts were adopted.

ELECTION OF OFFICERS, 1903-1904.

The SCRUTINEERS reported that the following officers had been elected for the ensuing year:—

PRESIDENT: Mr. ISAAC MEACHEM, Junr.

VICE-PRESIDENT: Prof. R. A. S. REDMAYNE.

NEW MEMBERS OF COUNCIL:

Mr. W. CHARLTON.	Mr. F. GRIFFITHS.	Mr. GEORGE TURNER.
Mr. W. J. DAVIES.	Mr. J. W. NEWEY.	Mr. W. H. WHITEHOUSE.

REPRESENTATIVE ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1903-1904.

The SCRUTINEERS reported the following appointment:—

Mr. W. F. CLARK.

The PRESIDENT then took the chair and delivered the following address:—

PRESIDENTIAL ADDRESS.

By ISAAC MEACHEM, Jun.

I need hardly say that it is impossible for me to express my appreciation of the honour that you have conferred by electing me your President for the coming year. I thank you most heartily for this expression of confidence, but I am somewhat troubled with a conscience, which will insist on asking what have I done to deserve the honour. As you have been pleased to confer this dignity upon me, it now remains for me to do my best to uphold and preserve the best traditions of the office. When I look back upon the former occupants of this Presidential chair, I see that I am following in the wake of many men of sterling qualities—truly great men: not brilliant men, who have briefly shone, meteor-like, across the sky and then gone out, or brilliant as stars which can be seen but not reached, but men of strong, earnest lives, whose great love was their profession, who raised its standard and enhanced its dignity. I need but mention three:—Never shall I forget Mr. Henry Johnson, Sen., who in my youthful days appeared to me so great as to be unreachable, but one day I found, though I could not reach him, that he could reach me, and his kindly words, his advice and help gave me a determination to follow him. Another was Mr. David Peacock, and it was my privilege to have him by my side in the first mining law-suit in which I was engaged. And also another, whom we miss to-day, whose familiar features were often seen at these meetings, whose interest in this Institute never abated from the time when he became a member in 1869 until the day of his death, Mr. W. J. Hayward. These were men ever ready to assist, counsel and advise their brethren; their true greatness lay in their high character and devotion to their profession; and, thus, they became ideals for the younger generation to follow.

I feel to-day, on the thirty-sixth Annual General Meeting of the members, that we ought to congratulate ourselves that our

Institute has attained so respectable an age. I well remember the birth of this Institute: at that time it was said by some, what is the use of such an Institute, in a coal-field which will soon become dead? It was then believed that the South Staffordshire coal-field, more especially the southern portion, was moribund. Truly, it has gone on dying in a remarkable manner, for it is livelier to-day than when it commenced to die; and those who from afar have been interested in watching its death-struggles have to confess that there is life in it yet. I believe that the old coal-field will yet find scope for the energies of many a budding mining engineer who is now engaged in preparing himself for his life-work in that profession.

I purpose to take "Mining Legislation" for the subject of my address. It is a subject that cannot fail to be of interest, and I trust that it will be of use to all; and later on, I propose to follow it with another address on the "Law Relating to Mines and Mining."

The need of legislation for our industrial occupations is acknowledged by all. Acts of Parliament generally consist of rules and regulations, drawn up on lines indicated by experience, for the proper conduct of mines, quarries and factories, and for protection of life, limb and health.

For our own profession of mining, during the past 50 years, Parliament has been busy, from time to time, devising and passing Acts for the regulation of mines; and whatever may have been the deficiency of rules and regulations previous to 1850, since then rapid strides have been made in the direction of rules and regulations for the safety of life and limb, and also, I may fairly say, for the protection of property.

Previous to 1736, neither rules, regulations nor Act of Parliament existed relating to mines. Most mines were worked in a happy-go-lucky style, little or no care being exercised with respect to ventilation or timbering. Miners were looked upon as a class by themselves, uncouth, ignorant and depraved; and they were practically serfs, beneath the notice of respectable men. Their only business was to work, and no one dreamed of rules and regulations for their protection. Therefore, one need not be surprised to find that the first Act of Parliament affecting mines was for the protection of the property of their

employers. It was then enacted that "if any person or persons shall wilfully and maliciously set on fire, or cause to be set on fire, any mine, pit or delph of coal, or cannel coal, every person so offending, being thereby lawfully convicted, shall be adjudged guilty of felony, and shall suffer death, as in cases of felony, without benefit of clergy."

This severe Act did not, however, appear to have been effective in stopping malicious injury to property, as in 1769, or 33 years after the former act, "The Malicious Injuries Act" was passed. It set forth that "any person or persons, who shall wilfully or maliciously set fire to or burn, demolish, pull down, or otherwise destroy or damage any fire-engine erected or to be erected, for draining water from collieries or coal-mines, or for drawing coals out of the same, or any bridge, wagon-way, or track erected or to be erected, for conveying coals from any colliery or coal-mine or staith for depositing the same; every such person being lawfully convicted of any or either of the said several offences, or of causing or procuring the same to be done, shall be adjudged guilty of felony, and shall be subject to the like pains and penalties as in cases of felony; and the court, before whom such person shall be tried, shall have power and authority to transport such felon for the term of seven years, in like manner as other felons are directed to be transported by the law and statutes of this realm."

The first two Acts of Parliament relating to mines were thus directly concerned with the preservation of property and punishment of the destroyers of same. And although explosions with considerable loss of life had occurred, and the necessity of ventilation was acknowledged, no Act of Parliament was passed, nor any rules laid down for the protection of life or limb. Mines were worked recklessly, with little or no care or regard for men's lives. Explosions, falls of roof, and loss of life or limb resulting therefrom were put down to accident or the will of God; and, incredible as it may seem, some persons looked upon all attempts to prevent accidents as an interference with the immutable will of God.*

* In fact, so late as 1876, an old charter-master expressed to me his view that the Coal-mines Regulation Act of 1872, was an impious attempt to override the will of God, and that depressed trade was a consequence of such impiety.

But long ere this, the mining "king of terrors," fire-damp, had made itself felt. One of the earliest records describes an explosion that occurred at Mostyn, North Wales, and caused great alarm, excitement and wonder. It took place on February 3rd, 1675. For some time gas had been found and fired in the mine, it had burned harmlessly, and was an object of curiosity and amusement, until a man was burned and disabled for life. Afterwards a "man of purpose" was employed to disperse or fire the damp before the men commenced work; he was dressed in wet flannels and carried a long stick with candles burning at the end, with which he searched for and fired the gas. On that morning, however, after the mine had been idle for a few days, an explosion occurred and in the quaint words of Mr. Roger Mostyn:—"The damp flew to and fro over all the hollows of the work with a great wind and a continued fire, and, as it went, keeping a mighty great roaring noise on all sides."

During the eighteenth century explosions occurred frequently, some involving loss of life for 70 to 80 persons; 360 lives were lost in explosions at which 10 and upwards of lives were lost in each explosion, to say nothing of those in which less than 10 lives were sacrificed. Naturally, these disasters, occurring with greater frequency every year, attracted public attention. On July 9th, 1800, an Act was passed "For the security of collieries and mines, and for the better regulation of colliers and miners." The first clause enacted that "any one filling up an airway, or damaging any part of a mine or roadway leading to it, or digging minerals from any waste, is guilty of felony and is to be transported for seven years."

Explosions still continued to take place, and public feeling was thoroughly aroused by an explosion at Felling colliery, near Gateshead, by which 92 lives were lost. An association was formed at Sunderland with the object of inquiring into the causes of such calamities, and of devising means for their prevention. Mr. John Buddle, the leading viewer and mining authority in the North of England at that time was approached, and in November, 1813, the society published its first report, containing a letter from Mr. John Buddle on the subject. He said that "the only method we are at present acquainted with for the prevention of accidents by fire is thorough ventilation

of the several passages and workings of the mine." He then mentions the various methods of producing ventilating currents, namely: —The furnace, the waterfall, the steam-ventilator, the air-pump and the heated air-pipe. He also described his methods of ventilating mines so as to bring fresh air always to the face of work, and his method of sweeping away gas by arrangements of air-doors and brattice-cloths. He also gave a description of the steel-mill, then the sole comparatively safe method of lighting a mine liable to fiery gas.

The Sunderland Society then applied to Sir Humphrey Davy to assist them with the problem of a safe light for use in fiery mines; and the direct result was the invention of the Davy safety-lamp in 1815. By a curious coincidence, Mr. George Stephenson, then colliery-engineer at Killingworth colliery, about the same time invented the Stephenson lamp. The main features of these lamps have continued to be the leading principles in the construction of safety-lamps to this day. Careful tests soon convinced experts that a most valuable discovery had been made; and they were, in fact, so satisfied with the lamps, that an opinion was expressed in 1816 that with the use of these lamps the days of colliery-explosions were over. The mistake was soon discovered, and in 1829 Mr. John Buddle stated that a greater loss of life had taken place since the introduction of the safety-lamp than for a corresponding number of years before.

The next legislative enactment affecting mines was the passing of the Truck Act in 1817; the first Act passed in the interests of the workmen. This Act provided "against payment of labourers in goods or by truck, and to secure their payment in the lawful money of the realm to labourers employed in the collieries or in the working and getting of coal in the United Kingdom of Great Britain and Ireland." This was simply the extension to colliers of a privilege that other labourers had enjoyed for nearly a century. This Act was amended in 1831, but nevertheless the law was openly violated, especially in South Staffordshire, where, although the workmen were paid in the coin of the realm, they were practically compelled to purchase all their goods at the master's tommy-shop, where all needful articles were sold, not always of the best quality

or at the lowest rate. I have a vivid recollection of these tommy-shops, and of the loud complaints of the men and women who were compelled to patronize them. It is but fair to add that under this reprehensible system money was expended for food for the family, which otherwise often would have found its way to the till of the publican. The Truck Acts of 1887 and 1896, however, effectually put an end to these shops.

We see, then, that the first Acts of Parliament affecting miners were (1) for the protection of property, and (2) for the protection of workmen's wages; but that nothing was enacted for the protection of life and limb.

In 1833, Mr. Carleton Tufnell, one of the H.M. Commissioners entrusted with the carrying out of the Factory Act, during his investigations in Lancashire, discovered that children, of both sexes, were employed in mines under such circumstances of barbarity and hardship as to be hardly credible in these days. He expressed his opinion in the following words:—"I cannot much err in coming to the conclusion, both from what I saw and the evidence of the witnesses given on oath, that it must appear to every impartial judge of the occupation, that the hardest labour in the worst room in the worst conducted factory is less hard, less cruel and less demoralizing than the best of coal-mines." This statement attracted much attention, and a movement was set on foot in the direction of ameliorating the condition of these unhappy children.

In 1840, a commission was appointed "to make enquiry into the employment of young children in mines and collieries, and in the various branches of trade and manufacture." The enquiry lasted 2 years, and disclosed the deplorable condition of the mining population. Infants, 3 or 4 years of age, were actually taken into the mines, and although that early age was exceptional, yet it was common to find that children 6 to 8 years old were sent down the pit. The employment of women and children was general in Scotland, in Yorkshire, in Lancashire and in South Wales. In South Staffordshire, child-labour in mines was so prevalent that the workhouses of Walsall, Wolverhampton, Dudley and Stourbridge were almost denuded of boys, the butty-colliers of that day having taken them out as apprentices. I have met old miners who stated that they

were taken from the workhouse to work in the mines at 6 and 7 years of age.

Following upon this enquiry, Lord Ashley's Act was passed in 1842, prohibiting the employment of women and young children underground. The Act provided that, after March 1st, 1843, no women or girls were to be employed underground, and no boys under the age of 10 years, except those who were already in the pits at the time; that no boy was to be apprenticed under the age of 10 years, nor for a period exceeding 8 years; that the wages were not to be paid at or near a public-house, and that the Secretary of State should be empowered to appoint proper persons to visit and inspect the mines and collieries. The clauses of the Act were enforced by imposing a penalty of not more than £10, or less than £5, on any person offending against them.

In July, 1844, Mr. H. S. Tremenheere, the inspector appointed under Lord Ashley's Act, published his first report. He described the beneficial effects of the Act, and stated that the colliery-proprietors had found it work to their benefit; for, as they no longer could employ women to drag the coal-tubs, they were compelled to use ponies, and the change proved to be economical. The miners, however, had laid before him their many grievances, such as bad ventilation, general mismanagement of the mines, and the vicious system of measuring or weighing their work and coal; and therewith commenced a long discussion on the subject.

In August, 1845, a commission was appointed consisting of Sir Henry de la Beche and Dr. Lyon Playfair "to make inquiries into the condition under which explosive and other noxious gases in mines are generated, and to ascertain, as far as possible, the nature and condition of these gases, and to advise as to the measures, if any, which can be applied in mitigation, if not prevention, of the evils inflicted through their agency." The report was completed in June, 1846. The commissioners anticipated that mines-inspection would tend to ensure the proper ventilation of collieries, efficient knowledge on the part of subordinate agents, and proper punishment for foolhardiness, or carelessness, on the part of the colliers. They also pointed out the great importance of keeping correct plans of the under-

ground workings, shewing the system of ventilation and the mode of getting the coal.

During 1846, explosions occurred at Risca colliery, South Wales, and at Round's Green colliery, Oldbury, in which 35 lives and 19 lives were lost respectively. Sir Henry de la Beche, who had been instructed to examine on these collieries, reported that in each case, great laxity of management was revealed and at Round's Green colliery, there was absolutely no system of ventilation. In 1847, the same revelations were made in an enquiry as to the loss of 72 lives by an explosion at Ardsley Main colliery, Barnsley; and at the inquest, the jury expressed the opinion that Parliament would be justified in "framing such a code of regulations as would give greater security to persons employed in mining operations."

The question of the inspection of coal-mines was also taken up by the men, and after several measures dealing with the subject had been brought before Parliament, a bill was passed in July, 1850. This Act provided for the appointment of inspectors, with authority to enter into and examine any colliery underground, as well as all the works, machinery and buildings on the surface, at any time, and enquire into all matters relating to the safety of the men employed. In the case of danger existing, the inspector was to point out such danger to the manager, and if the defect was not remedied within a reasonable time he was required to report the case to the Secretary of State. Fatal accidents were to be immediately reported to the Secretary of State. Correct mining plans were to be kept and maintained, and to be produced to inspectors when required.

This was the first Act of Parliament touching the actual management of the mine, and the first instalment of our present-day elaborate system of inspection and regulation. The Act of 1842 was not repealed and still remained in force, and there were two inspectors under the Act of 1842, and four mine-inspectors under the Act of 1850.

The inspectors under this Act soon found, that if they were to do good, their powers must be extended, and in 1855 "An Act to amend the Law for the Inspection of Coal-mines in Great Britain" was passed. The important feature of this Act

was a clause embodying seven General Rules; provision was made for Special Rules for the particular requirements of each district, to be framed and put into force at every colliery, and the duties of mines-inspectors were defined. For breaches of the Act or Special Rules, the owner or responsible agent was liable to a penalty not exceeding £5, and £1 per day during the time that the offence continued after notice had been given; while the workmen were liable to a fine not exceeding £2, and also imprisonment not exceeding 3 months.

The General Rules under this Act were as follow:—

1.—An adequate amount of ventilation shall be constantly produced at all collieries to dilute and render harmless noxious gases to such an extent as that the working-places of the pits and levels of such collieries shall under ordinary circumstances be in a fit state for working.

2. Every shaft or pit, which is out of use, or used only as an air-pit, shall be securely fenced.

3.- Every working and pumping pit or shaft shall be properly fenced, when not at work.

4.—Every working and pumping pit or shaft, where the natural strata under ordinary circumstances are not safe, shall be securely cased or lined.

5. Every working pit or shaft shall be provided with some proper means of signalling from the bottom of the shaft to the surface, and from the surface to the bottom of the shaft.

6.—A proper indicator to show the position of the load in the pit or shaft, and also an adequate brake, shall be attached to every machine, worked by steam or water power, used for lowering or raising persons.

7.—Every steam-boiler shall be provided with a proper steam-gauge, water-gauge, and safety-valve.

In the South Staffordshire district, a code of 32 Special Rules was framed, defining the duties of the manager or ground-bailiff, engineer, engine-tender, banksman and hooker-on, charter-master and collier.

To carry out the provisions of this Act, six additional mine-inspectors were appointed, and districts assigned to them.

In 1860, this Act was amended and renewed under the title of "An Act for the Regulation and Inspection of Mines." This Act extended to the ironstone-seams of the Coal-measures; the age of prohibition of boys was raised from 10 to 12 years; persons in charge of winding-engines were not to be under 18 years of age; and all serious non-fatal accidents were to be reported to the inspectors of mines. Some of the General Rules of the Act of 1855 were modified, and the following eight additional General Rules were added:—

2.—All entrances to any place not in actual course of working and extension, and suspected to contain dangerous gas of any kind, shall be properly fenced off so as to prevent access thereto.

3.—Whenever safety-lamps are required to be used, they shall be first examined and securely locked by a person or persons duly authorized for this purpose.

8.—All underground self-acting and engine-planes, on which persons travel, are to be provided with some proper means of signalling between the stopping-places and the ends of the planes, and with sufficient places of refuge at the sides of such planes at intervals of not more than twenty yards.

9.—A sufficient cover overhead shall be used when lowering or raising persons in every working pit or shaft where required by the inspectors.

10.—No single-linked chain shall be used for lowering or raising persons in any working pit or shaft, except the short coupling chain attached to the cage or load.

11.—Flanges or horns of sufficient length or diameter shall be attached to the drum of every machine used for lowering or raising persons.

14.—The fly-wheel of every engine shall be securely fenced.

15.—Sufficient bore-holes shall be kept in advance, and, if necessary, on both sides to prevent inundations in every working approaching a place likely to contain a dangerous accumulation of water.

A code of 45 Special Rules was drawn up for the South Staffordshire district: an increase of 17 upon those previously in force.

In 1862, an accident occurred at Hartley colliery and 204 lives were lost. The mine was worked by a single shaft, divided by a wooden partition or brattice. In one division of the shaft, were the pump-rods, worked by an engine-beam, which hung over the shaft. The pump-rods broke, the beam came suddenly down upon the catch-pin, snapped in two, and part of it, about 13 tons in weight, fell down the shaft, crashed through the brattice, choked the shaft with débris, stopped the ventilation and the whole of the men in the mine were suffocated. In consequence of this accident, an Act was passed in 1862 "to amend the Law relating to Coal-mines," prohibiting the working of coal-mines and ironstone-mines, without at least two means of exit for the men.

These Acts, although not actually diminishing the number of lives lost annually, have very considerably reduced the ratio of lives lost by accident to the number of men employed.

For 1851, the first complete year of the "Act for Inspection of Coal-mines in Great Britain," the proportion of lives lost by accident to the number of men employed was 1 in 219. For

1855, it was 1 in 254, or a reduction of from 4·55 to 3·93 per thousand: a result fully justifying the passing of that Act.

In 1856, the year in which "An Act to amend the Law for the Inspection of Coal-mines in Great Britain" came into operation, the proportion was 1 in 242; and in 1860 it was 1 in 248, or a reduction from 4·12 to 4·02 per thousand.

In 1861, when the "Act for the Regulation and Inspection of Mines" came into force, 1 in 299 of the persons employed was the accidental death-rate, and in 1872, it was 1 in 394, a reduction from 3·34 per thousand in 1861 to 2·53 per thousand in 1872, a difference of 0·81 per thousand. This diminution occurred, despite the fact that during this period terrible explosions occurred at the Oaks colliery, when 361 lives were lost, and at Ferndale colliery, at a further sacrifice of 178 lives.

The reduction from 4·55 per thousand in 1851 to 2·53 per thousand in 1872 was 44·4 per cent.

At this time, the experience gained by the inspectors of mines as to the beneficial operation of the various Acts of Parliament in reducing the death-rate from accidents, to say nothing of the reduction of non-fatal accidents, enabled them to render valuable assistance to the Government in framing "An Act to consolidate and amend the Acts relating to the Regulation of Coal-mines and certain other Mines," 1872. This Act came into force in England and Scotland on January 1st, 1873, and in Ireland on January 1st, 1874.

The Act of 1842 was repealed, its provisions being embodied in the Act of 1872, and inspection confined to one body of inspectors of mines. This Act consisted of 76 sections and contained 31 General Rules. In the South Staffordshire district a code of 59 Special Rules was adopted, including a code of signals.

An entirely new feature of this Act dealt with managers of mines, who, for the first time, were required to hold certificates. These certificates were of two kinds:—(1) A certificate of service "granted by a Secretary of State to every person who satisfies him either that before the passing of this Act he was acting and has since that day acted, or that he has at any time within five years before the passing of this Act for a period of not less than twelve months acted, in the capacity of a manager

of a mine or such part of a mine as can under this Act be made a separate mine for the purposes of this Act;" and (2) a certificate of competency granted by examination before a board of examiners. The composition of the board of examination, which elected the examiners, was also defined.

This was the result of loud-voiced complaints concerning the ignorance of many of the then mine-managers; and the members of the various commissions which made enquiries as to the causes of accidents in mines, in their reports invariably spoke strongly upon this point. The inspectors of mines also emphasized the lamentable lack of training of mine-managers, and the necessity of their being properly trained for their duties.

During the operation of this Act, the reduction of accidents per thousand men employed was very noticeable. The proportion of fatalities in 1872 was 1 in 394 or 2·53 per thousand; and in 1887, the last year under this Act, it was 1 in 540, or 1·85 per thousand, a reduction of 27 per cent. or of 60 per cent. of the loss of life in 1851: a record shewing that in 36 years the loss of life by accident in mines had been reduced by 60 per cent.

In 1887, a further step in mining legislation was taken by the passing of the "Coal-mines Regulation Act," or as it is entitled "An Act to consolidate with amendments the Coal-mines Acts, 1872 and 1886, and the Stratified Ironstone-mines (Gunpowder) Act, 1881." This Act makes provision that under-managers should hold certificates; a second-class certificate being provided for the purpose, "but the nomination of an under-manager shall not affect the personal responsibility of the manager under the Act."

This Act, together with the Act of 1896, is still in force, and, therefore, familiar to all of the members, hence I need not allude to its provisions.

The general effect of legislation on the saving of life in mines is shown by the results recorded in Table I. In 1851, the loss of life was 984; the same percentage of loss in 1902 would be 3,754; and the difference of 2,730 represents the saving of life in 1902 as compared with 1851. The present death-rate among miners is the lowest for all workers, except agricultural labourers.

TABLE I.—DEATH-RATES FROM ACCIDENTS PER 1000 PERSONS EMPLOYED.

Years.	Underground.					Surface.	Underground and Surface.
	Explosions of Fire-damp or Coal-dust.	Falls of Ground.	Shaft-accidents.	Miscellaneous.	Totals.		
1851	1·867	1·902	1·274	0·425	5·469	0·993	4·551
1902	0·092	0·686	0·154	0·438	1·370	0·687	1·231
Reduction of death-rate	1·775	1·216	1·120	*0·013	4·099	0·306	3·320
Percentage reduction of death-rate	95·07	63·94	87·92	*3·05	74·95	30·81	72·95

* Increase.

A remarkable feature of Table I. is the great reduction under the heading of explosions of fire-damp or coal-dust, testifying to the vastly improved methods of mine-ventilation, and to the care and skill devoted to the ventilation of mines, much deeper and more fiery than any worked in 1851. The falls of ground, although the figures are not so favourable as those under the first heading, show a steady improvement, which is evidence that managers and men should pay every attention to timbering, and that every official should make a point of seeing that timber is set systematically and properly. Shaft-accidents, next to explosions, show the greatest improvement. The miscellaneous accidents have increased, and this suggests that workmen should use greater care when engaged on haulage or inclined planes, and in the handling of explosives: these two items alone being responsible for 50 per cent. of the deaths.

It is, however, an injustice to colliery-proprietors and mining-engineers to attribute the saving of life and limb entirely to the effect of mine-legislation. They have contributed in no small degree by their anxiety to employ the best machinery: in many cases no pains or expense has been spared to lay out the mining plant in a perfect manner, and every assistance has been afforded in framing Special Rules for their collieries and districts.

The enhanced respect for life and limb has rendered mining engineers keen to detect and provide against any possible danger to life and limb; and it is questionable whether, at the

present day, there is any profession more keenly alive to the safety of the workpeople under its care than that represented by those who have the charge and management of mines. And I believe that if the Coal-mines Regulation Act were repealed, the provisions of that Act would be voluntarily carried out at many collieries in their entirety, in the interests both of life and limb and of economy and comfort: the best regulated collieries being the most economically worked.

From legislation affecting the working and management of mines, I now turn to legislation affecting compensation to injured workmen or to their relatives. There are two laws bearing specially on this subject, namely:—The Employers' Liability Act, 1880, and the Workmen's Compensation Acts, 1897 and 1900.

Before the passing of the Employers' Liability Act, a workman, at common law, practically could not recover damages for injuries sustained by the negligence of a person in the common employment, although the neglectful person might be one of a higher grade or even in authority. This Act did away with this disability of the workman, so that a workman, when suing under any section, ceases for all intents and purposes to be a servant, and sues as one of the public. Lord Justice Bowen said that "The workman . . . . shall have the same right of compensation and remedies against the employer as if the workman had not been a workman of, nor in the service of, the employer nor engaged in his work."

In 1897, The Workmen's Compensation Act was passed which provided that "if in any employment to which this Act applies personal injury by accident arising out of, and in the course of, the employment is caused to a workman, his employer shall, subject as hereinafter mentioned, be liable to pay compensation in accordance with the First Schedule to this Act."

The Employers' Liability Act rendered the employer liable, when defect, negligence, act or omission could be proved; but the Workmen's Compensation Act omits these provisions, and provides compensation for all accidents arising out of and in course of the employment, except during a period of two weeks immediately after the accident. This Act does not in any way repeal or affect the Employers' Liability Act, and the workman

is at liberty to take action under either Act; but once he had chosen under which Act to claim compensation he must abide by that decision. This clause, however, is modified by the provision that if "an action is brought to recover damages independently of this Act for injury caused by any accident, and it is determined in such action that the injury is one for which the employer is not liable in such action, but that he would have been liable to pay compensation under the provisions of this Act, the action shall be dismissed; but the court in which the action is tried shall, if the plaintiff shall so choose, proceed to assess such compensation, and shall be at liberty to deduct from such compensation all the costs which, in its judgment, have been caused by the plaintiff bringing the action instead of proceeding under this Act." Hence, if proceedings under the Workmen's Compensation Act are brought and are unsuccessful, no further claim can be made; but if an action under the Employer's Liability Act, or at common law is first brought, it is still open to the workman, at the hearing, to apply for compensation under the Act.

It was feared that the passing of these Acts would place great expense upon the employers, and that endless litigation would ensue; but during the few years that these Acts have been in operation, these fears have not been realized. In 1902, the number of deaths from accident in mines was 1,053, and 151 cases were brought before arbitrators under the Workmen's Compensation Act, or 14·34 per cent.; and 3 cases under the Employer's Liability Act or 0·28 per cent., a total of 154 cases or 14·62 per cent. The cost had been rather less than 10s. per £100 of wages paid. There was a diminution of cases as compared with 1901, shewing that there is a tendency to arrange the amount of compensation amicably.

Under the Workmen's Compensation Act "if the Registrar of Friendly Societies, after taking steps to ascertain the views of the employer and workmen, certifies that any scheme of compensation, benefit or insurance for the workmen of an employer in any employment, whether or not such scheme includes other employers and their workmen, is on the whole not less favourable to the general body of workmen and their dependants than the provisions of this Act, the employer may, until the certificate is revoked, contract with any of those workmen that the pro-

visions of the scheme shall be substituted for the provisions of this Act, and thereupon the employer shall be liable only in accordance with the scheme, but, save as aforesaid, this Act shall apply notwithstanding any contract to the contrary made after the commencement of this Act." Under this clause, 47 certified schemes are in operation, and although, at first, this clause was viewed unfavourably by the workmen, it is now growing in favour.

A scheme is in operation in the South Staffordshire district that works with great satisfaction, and is of great advantage to the men. The men pay 2d. per week, the boys 1d. per week, and the employers pay 4d. per man and 2d. per boy employed. If a man be injured, he receives from the day of the accident 10s. per week, and boys 6s. per week. Consequently no question is raised as to the average rate of earnings, as the bulk of the accidents are but slight, involving but a few day's absence from work. Fully 55 per cent. of the injured persons receive benefits, but under the Workmen's Compensation Act they would not receive any compensation. Remarkably few cases under this scheme are taken before an arbitrator, and worry and anxiety to both masters and men are thus avoided.

The Act, in some cases, bears hardly upon employers: men of drinking habits, and those, generally, whose constitution has been shattered, are injured whilst at work; the injury to a man of sober and steady habits would be trifling, but in such cases it often proves serious and even fatal, and the employer is required to pay compensation under the Act. In some cases, a rule is enforced that no man of known intemperate habits shall be employed in or about the mine.

Mining-engineers and colliery-managers have heavy and responsible duties, comprizing the safety and health of their workmen, and the protection of their employers' interests, and both require constant vigilance and care. It must, however, be borne in mind that these duties are not antagonistic: they are complementary to each other. Safety, efficiency and economy are the watchwords of mining-engineers: to provide for the safety of the men, is to be efficient, and that is true economy. The work is arduous, and full of anxiety and care; but, with the ideals of safety, efficiency and economy before them, whatever

the results may be, mining-engineers have the consciousness of having done what they could to fulfil the sacred trusts committed to their charge.

In conclusion, legislation has been of immense benefit to the mining industry, and although it was feared by many that it would be hampered, the industry has steadily prospered. In 1850, the output of coal was estimated at 50,000,000 tons, and 200,000 persons were employed; in 1873, the output was 143,041,246 tons, and 514,149 persons were employed; and in 1902, the output was 239,717,699 tons and 824,791 persons were employed. The increase during the last 30 years of over 51 per cent. in output, carries with it the conviction that all industries dependent on coal must have progressed likewise.

I find, although not strictly within my subject, that the average tonnage of mineral drawn varies inversely as the progress of trade during the year. In 1873, a year of good trade, 277·8 tons were drawn per man employed, while in 1885, a time of depression, 332·4 tons were drawn per man, a difference of nearly 20 per cent. In viewing a series of years, it will be found to be the rule that the better is trade the lower is the tonnage, and inversely the greater the depression the higher the tonnage—a fact which should engage the serious attention of all concerned, as the loss in good trade of nearly 20 per cent. of the product of men's labour is sure to shorten the period of prosperity and hasten the time of depression.

A cordial vote of thanks was accorded to the President for his address.

Dr. A. Simon's paper on "Coal-cutting Machinery of the Percussion-type" was read as follows:-

COAL-CUTTING MACHINERY OF THE PERCUSSION-TYPE.

By A. SIMON.

The object of the coal-cutting machine is to cut a groove or channel into the coal, thus making a clearance, which allows of the coal being broken down, or up, either by explosives or wedging, without an undue amount of small coal being produced. If the groove be placed parallel to the coal-seam it is called a cut or an undercut; and the art of making such a groove is called cutting, holing or kirving. If the groove be placed perpendicularly to the coal-seam, it is called a shear or a vertical cut; and the art of making such a shear is called shearing or nicking the coal.

Ever since coal has been wrought, kirving and nicking the coal has been done with the miner's pick; and ever since the introduction of machinery to replace hand-labour, it has been the endeavour of inventors to design machines to kirve and nick the coal. These machines are called coal-cutting machines or coal-cutters.

In designing the first coal-cutting machines, one set of inventors has evidently endeavoured to obtain an action similar to that achieved by the miner with his pick; another set of inventors has endeavoured to adapt the action of the circular saw to coal-cutting purposes; and another set has made use of a bar provided with teeth to cut the desired channel. The various classes of coal-cutting machinery may be classified as follows:—(1) Rotary machines: including (*a*) disc-machines, (*b*) chain-machines, (*c*) bar-machines, (*d*) scythe-machines and (*e*) circular groove-cutting machines. (2) Pick-machines, including: (*a*) those on wheels, (*b*) on a frame, and (*c*) on a rigid support.

(1) *Rotary Machines.*—The machines mentioned under the first class are driven either by electricity or compressed air. Of the rotary machines, disc-, chain- and bar-machines are being used for longwall-work; for such work the machines are mounted on wheels, and while cutting they are automatically moved along the coal-face. Some of these machines have proved very successful, and their usefulness cannot be gainsaid.

Chain-machines and bar-machines of special construction, called breast-machines, mounted on frames, have been and are being used for under-cutting, and in isolated cases for working the coal in rooms or narrow headings. Chain-machines alone, however, are now in use for such work, bar-machines having generally found their way to the scrap-heap. It remains to be seen whether a better future is in store for the chain-breast machine; as, in spite of fast cutting, machines of this type have numerous disadvantages. When air-driven, they consume a considerable amount of power, necessitating pipe-lines of large diameter: the machines are necessarily heavy, and their transport from one working-place to another is not an easy matter; close timbering or close packing is impossible, as the machines require from 10 feet to 14 feet of clear space in front of the working-face, and with a doubtful roof their use must be prohibited. Electrically-driven machines of this type, so far as power-consumption is concerned, are approved; but the repair-bill is generally a high one.

Of the other rotary machines mentioned, the scythe-machine, constructed by Mr. Paul Fayol, in 1889, is very little known, and only interesting from a historical point of view (Fig. 11, Plate VIII.).*

The best-known type of the circular groove-cutting machine, is the Stanley heading-machine, a rather cumbersome appliance, and a large consumer of power.

All rotary machines, whether electrically- or air-driven, are heavy and expensive; each of them is designed for one special class of work only, and cannot possibly be used for any other purpose. A disc- or chain-machine, designed to cut in a dirt-band, say 6 inches from the floor, cannot be used to cut either close to the floor or above the dirt-band, and its use is generally

* "Expériences de Havage Mécanique," by Mr Paul Fayol, *Comptes-rendus Mensuels des Réunions de la Société de l'Industrie Minérale*, 1889, page 171.

limited to one seam only. The rotary nicking-machine must be adapted to the height of the coal-seam, and it is therefore of no use in a seam of different dimensions. The same remark applies to the use of the Stanley heading-machine.

(2) *Pick-Machines.*—Pick-machines, such as can lay claim to successful work, are all air-driven. Pick-machines on wheels were first introduced in 1887 by Mr. Harrison, and have, in their general appearance, hardly undergone any change since that date. These machines are extensively used in the United States. In 1899, about 2,000 were at work in the mines, and since then their number has increased very considerably. The machines best known are the Sullivan, Ingersoll-Sergeant, and the Harrison. It is difficult to say that any one of these machines is the best, as all the makers are constantly improving them. One mine-manager, who was quite unprejudiced about any of them, has informed the writer that from time to time new types are put on the market by the various makers, and in his experience the latest type is generally the best machine.

A pick-machine of this type, mounted on wheels 16 inches to 20 inches in diameter, according to the requirements, weighs from 500 to 750 pounds, and is easily moved from one working-place to another: the time consumed in moving from room to room of average length, including loading and unloading, being about 10 minutes. In operation, the machine is placed on a platform made of pine, 2 inches thick, about 8 feet long and 3 feet wide, which is so inclined towards the face, by means of a trestle placed under the outer end, that the recoil of the machine is neutralized by gravity and feeds down gradually into the coal.

The method of mining is as follows:—The runner sits on the platform behind the machine, which he holds by the handles: the pick is shot against the coal by means of compressed air, at a pressure of from 40 to 90 pounds per square inch, striking with a force and speed which can readily be adjusted to range from 160 to 250 blows per minute, and a force per blow of from 5 to 1,000 pounds. The runner uses a block, attached to his shoe by a strap, to chock the wheels of the machine against the recoil. He first undermines to a depth of about 12 inches, with an average height of 4 inches; with a few blows placed higher

up, the coal is blocked down in chunks to a height of 14 inches, sloping towards the back. This process is repeated until there is no longer any necessity for the blocking, and the last 2½ feet are finished by under-mining to an average of 3 inches only in height, about 5 feet of face being cut with one setting of the board.

While the machine is at work, the helper shovels or scrapes the small coal produced out of the cut as it is made.

By undercutting in this way, a large proportion of the minings are lump- and nut-coal, with less slack or small coal. By ordinary careful work, more than one-half of the undercuttings will go over a screen with bars 1¼ inches apart, and, of the remainder most will be nut and pea.

When the first cut, from 4 to 5 feet wide, is finished, the board is moved across the face and another cut commenced, this shifting of the board taking only 2 minutes; and the same process is repeated until the under-mining of the room is completed. The machine is then loaded on a truck and run into another room, where it can be at work again in from 5 to 10 minutes, the truck and machine together weighing so little that they can be easily handled by the runner and his helper.

From this description, it will be seen that the machine makes its cut close to the floor of a seam; and the large number of applications, particularly in the United States, shows its usefulness for that purpose. The seam, however, must not be an inclined one.

It has been claimed that the machine could be used also for nicking the coal; to do such work the wheels on which the machine is mounted are of large diameter, so that it can swing in a plane perpendicular to the axis of the wheels. This application does not, however, deserve much attention, as it has been fully demonstrated that it is of no practical value.

The great drawback to the use of pick-machines on wheels, and the chief reason why they have not found favour with miners in Great Britain or on the Continent, is that the operator and particularly the novice, is subject to severe shaking through the recoil.

In America, runners are paid by the amount of work done, and prices are fixed for each district and for each seam. A good runner cuts in a shift five rooms, 20 feet wide and 5½ feet

under, that is 550 square feet per shift in a seam of average hardness. This amount of work is rarely exceeded, and is considered a good performance. To maintain the output and the reputation of their machines, American makers periodically send pacemakers to the various mines. These pacemakers are the record-breakers among runners from various mines. Their pay is as high as £30 per month, travelling and out-of-pocket expenses not included.

The first pick-machines had cylinders about 3 inches in diameter; but those most in favour now have cylinders about 5 inches in diameter.

Pick-machines on a frame fitted with wheels, include the Sullivan shearing-machine, the Wrightson-Morison machine and the Patterson coal-cutter. The former consists of a rock-drill mounted on an axis, fixed in a heavy frame so that the drill can swing in a vertical plane. The machine has been tried for nicking purposes, and so far as the writer is aware, in Illinois only. It yielded good results, but its heavy weight has prevented it from being adopted extensively. The writer regards it as belonging to the historical productions of coal-cutting machinery.

The Wrightson-Morison machine, and the Patterson machine, consist of two air-cylinders mounted on a frame supported by wheels. It is understood that the former machine cuts coal at a rapid rate.

Of machines mounted on a rigid support or column the writer will describe in detail their prototype, the Champion coal-cutter (Figs. 1 and 2, Plate VIII.). It consists of five essential parts, namely:—(1) The supporting column, A, with clamp, B: the weight varies according to length, and a column, 5 feet long, weighs about 200 pounds. (2) The segment, C, weighing about 114 pounds. (3) The drill, D, the largest size weighing about 239 pounds. (4) The extension-rods (five), E, 20, 40, 60, 80 and 100 inches long respectively, for cutting to a depth of 7 feet; the average total weight is 80 pounds. (5) The cutting-bit, F.

The supporting column is of simple and substantial construction. It is supplied in three varieties, namely:—Type A,

with nut and counter-nut; type B, with ratchet-attachment; and type C, fitted with an hydraulic ram. Each column can be extended by 1½ feet, so that a column 3 feet long might be lengthened by 1½ feet to 4½ feet. The hinged clamp, which slides longitudinally on the column, can be locked to the same at any desired height by means of the bolt and nut. Each column is also provided with a suitable setting-ring. The length of the column, when the screw or ram is home, should be from 3 to 6 inches less than the thickness of the seam or height of the mine in which the machine is to be used.

The toothed segment, C, is carried in a bearing of the clamp, B, and may be rocked and fastened therein from a horizontal to a vertical plane, or in any intermediate position. Pivoted in the hub of the segment and in its axis is a connecting-piece provided with a double-bearing for the reception of the drill, D, and actuated by a worm, G, gearing into the teeth of the segment. The spindle, driving the worm, is threaded at both ends, and the handle or handles for actuating the same can be attached to either end.

The working of the machine is controlled by one man or a boy, who, with one hand turning the handle of the worm, produces a swinging action of the drill, while, with the other hand, he regulates the advance of the drill into the coal by turning as in an ordinary rock-drill. To put the machine into position for working, the column, A, is made fast between the floor and roof of the seam at a distance of about 3 feet from the coal-face. The segment, drill and connecting rod, with cutting-bit are then put into position. When fixed, the feed-screw, *a*, of the drill, projects about 3½ feet to the back of the column; the furthest distance, therefore, from the coal-face to which the drill extends is about 6½ feet. If necessary, props might, however, be put into position much closer to the face on either side of the column, provided that they do not impede the swinging motion of the drill (Figs. 3, 4 and 5, Plate VIII.). When the drill is set to work, the cutting-bit strikes the coal at the rate of about 350 blows per minute. It penetrates very quickly into the coal, if the blows are directed to one place only; but while the machine is at work, the cutting-bit is gradually displaced in a plane parallel to the segment, by turning the handle of the worm; and the cutting-bit therefore strikes every blow in

close proximity to the preceding one. It describes an arc having for its centre the axis of the segment, and the outcome of this motion is a perfect cut. When the cutting-bit has reached the end of an arc, the drill is advanced to the extent that it has been cutting into the coal by turning the feed-screw, and the motion given to the worm is then reversed. When the drill has been advanced to the full extent of the feed-screw, that is $1\frac{3}{4}$ to 2 feet, the machine is stopped and the drill is screwed back to its starting-point, while the rod connecting the drill with the cutting-bit is replaced by a longer one.

The connecting-rods are made of steel with conically-turned ends; this enables the bit to exert a good grip on the connecting-rod, and this latter on the piston-head of the drill, while at the same time these parts can be disconnected easily, so that the exchange of one connecting-rod for another only occupies a few seconds.

The drill has a piston, $3\frac{1}{2}$ inches in diameter, with a stroke varying from 4 to $7\frac{1}{2}$ inches. The valve is air-driven. A special feature is an air-cushion in front of the piston, and this prevents the latter from striking the front cylinder-cover with undue force should the cutting-chisel miss the coal and strike into empty space. The piston is provided with a twist-nut, so that during the back stroke the piston is revolved by one-eighth of its circumference.

The cutting-bit is made of the best tool-steel and is provided with an odd number of radially-disposed cutting-edges or teeth. An odd number is necessary to prevent the cutting-bit from sticking in the cut. Lately, a central prong projecting beyond the radial teeth has been added, and satisfactory results have been obtained with this new cutting-bit. The central prong projects to different lengths for various qualities of coal, and is also varied in shape; in soft coal, it projects about 1 inch, and is flat-chisel shaped, while in hard coal, the amount of the projection is reduced to $\frac{1}{4}$ or even $\frac{1}{8}$ inch, and it is then provided with a diamond-shaped end. The most satisfactory results have so far been obtained with bits the radial teeth of which have been forged out of one piece of steel. Bits, with removable teeth, have not yet proved successful. The crown of the cutting-bit is about 3 inches in diameter, and the cut is made about 3 inches wide. For expanding coal, bits of decreasing diameter are used for consecutive extension-rods.

From one setting, the machine could make a cut up to 20 feet wide (Figs. 6 and 7, Plate VIII.). The depth is generally limited to 6 feet, although it has been extended in special cases to 12 feet. Cutting and nicking could be made from one setting of the column (Figs. 8 and 9, Plate VIII.).

As the drill is pivoted round a fixed point, the end of the cut is arc-shaped; if it is decided to square out the corners, a longer connecting-rod is used, and is directed in gradually-decreasing arcs first towards the one, and then towards the other corner of the cut (Figs. 3, 5 and 8, Plate VIII.). The machine can also be utilized as a wedging-machine (Fig. 10, Plate VIII.).

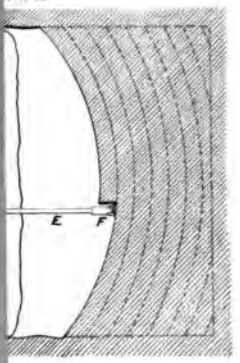
As to speed of cutting, it is evident that it is a function of the available air-pressure, the hardness of the coal, and the skill of the operator. Under favourable circumstances, 90 square feet have been cut per hour; while a fair average for a whole shift, including the shifting of the machine, might be taken to be 42 square feet in rooms or stalls, and five narrow headings might be holed and nicked in one shift of nine hours (Figs. 7 and 9, Plate VIII.).

It is usually admitted that coal-cutting by machinery is faster than coal-cutting by hand; and generally speaking, the harder the coal, the better are the results from machine-cutting. There is, however, an exception to this general rule, in that part of the steam-coal district in South Wales, where machinery is needed only for opening out work. An important point, however, is the cost of cutting per ton of coal produced. Opinions are very divided on this subject, as it is difficult to compare the results either of hand-labour against machine-work, or the work of one machine against another. The results gained in one seam do not necessarily apply to another, and the conditions of one mine are often so totally different from those in another that comparisons seem almost impossible. The chief difficulty of comparing results is, however, found in the different way in which records of work done are kept at the various mines. One colliery stated that machine-cutting saved, say, 4d. per ton of coal produced; in another, it was stated that the price of cutting coal amounted to 2s. 6d. per stint; in yet another, the cost was given per linear yard; and very few stated the cost of the superficial area in square feet cut by a machine. The best units on

which prices should be based seem to be either the sq foot or the square yard of kirving or nicking done. The t cost for such a unit should include:—Labour, explosive wedging, consumption of power, sharpening of tools and repa together with the redemption of the cost of the power-mach the coal-cutter, and the pipe-lines or cables. In addition to cost of cutting per superficial unit and for each particular s there ought to be stated:—The thickness of the seam, the of coal per square unit, the ratio of round coal to slack, and material in which the cut is made.

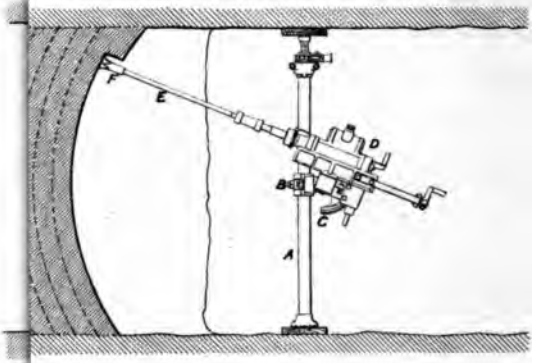
A cordial vote of thanks was accorded to Dr. A. Simon his paper.

ORIZONTAL CUT IN A DRIVE,
EQUIRED FOR THE
HINE.



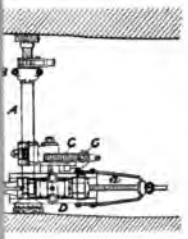
FIG

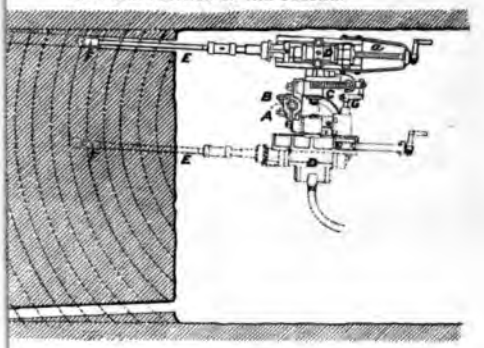
FIG. 5.—ELEVATION OF A MACHINE SET FOR SHEARING.



-PLAN OF A MACHINE SET FOR SHEARING (IN CONTINUOUS LINES)
AND A MACHINE SET FOR HOLING (IN DOTTED LINES),
FROM ONE POSITION OF THE COLUMN.

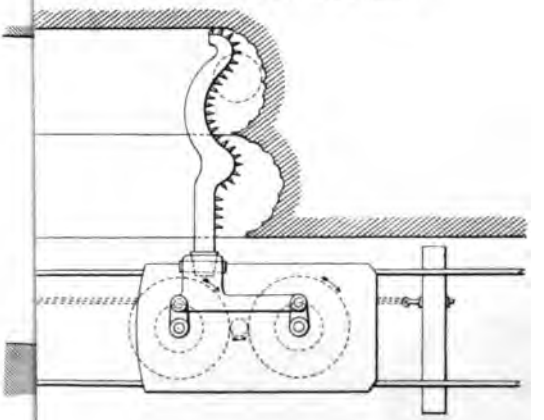
UTTING CLOSE TO THE FLOOR





HOWING UNDERCUTTING,
,AT EACH SIDE,
.

FIG. 11.—PLAN OF A FAYOL SCYTHE MACHINE.



THE INSTITUTION OF MINING ENGINEERS.

FOURTEENTH ANNUAL GENERAL MEETING,

HELD IN UNIVERSITY COLLEGE, NOTTINGHAM, SEPTEMBER 2ND, 1903.

SIR LINDSAY WOOD, BART., RETIRING-PRESIDENT, IN THE CHAIR.

Sir SAMUEL JOHNSON, in the unavoidable absence of the Mayor of Nottingham (Mr. Black), offered a welcome to the members. Mining engineers had to do with most of the important industries of the country, and especially of this district, and they were doing the city a great honour in becoming its guests. He could not refrain from saying how very important had been the services rendered to the country by mining engineers, by the intelligence and ingenuity brought to bear on the work of producing the coal, and on the improvement in the working conditions of the labour which raised it to the surface. He trusted that the members would be gratified with their visit, that they would learn from what was to be seen here, and afterwards retain pleasant recollections of Nottingham.

Sir JOHN TURNEY also spoke in welcome, and while wishing every success to the working of coal, he hoped that the waterworks in this district, upon which there had been considerable outlay, would not be detrimentally affected thereby.

The CHAIRMAN (Sir Lindsay Wood, Bart.), in acknowledging the kindness of the reception, said that Nottingham was one of the most important districts in Great Britain for its manufacturing industries, and would no doubt have some important lessons to teach.

ELECTION OF OFFICERS, 1903-1904.

The SECRETARY announced the election of officers for the ensuing year by the Council as follows:—

PRESIDENT:

Mr. J. C. CADMAN.

VICE-PRESIDENTS:

MR. HENRY AITKEN.	MR. JOHN GERRARD.	MR J. B. SIMPSON.
Mr. WILLIAM ARMSTRONG.	MR. W. B. M. JACKSON.	MR. A. L. STEAVENSON.
MR. G. E. COKE.	MR. G. A. MITCHESON.	MR. J. G. WEEKS.
MR. JOHN DAGLISH.	MR. R. T. MOORE.	MR. R. S. WILLIAMSON.
MR. J. T. FORGIE.	MR. H. B. NASH.	

AUDITORS:

MESSRS. JOHN G. BENSON AND SONS, Newcastle-upon-Tyne.

TREASURERS:

MESSRS. LAMBTON AND COMPANY, The Bank, Newcastle-upon-Tyne.

Sir LINDSAY WOOD, Bart. (Retiring-President), then vacated the chair in favour of his successor.

The PRESIDENT (Mr. J. C. Cadman), in taking the chair, proposed a vote of thanks to the retiring-President, Vice-Presidents and other members of the Council. Sir Lindsay Wood's presidency had been unique, because it marked the fiftieth anniversary of the foundation of the first mining Institute: Sir Lindsay Wood's father, the late Mr. Nicholas Wood, being the first President. The words which that gentleman used in his inaugural address fifty years ago might be fittingly recalled:—"Let each and every one of us try and act as if we considered ourselves individually responsible for the success of the Institute, and I have no doubt that our efforts will be successful." If these words were still taken to heart the Institution would continue to grow and flourish.

Mr. W. B. M. JACKSON seconded the vote of thanks, which was very warmly adopted.

Sir LINDSAY WOOD, Bart., in acknowledging the vote of thanks, said he felt sure that the meetings of the members promoted the advancement of the science of mining and the saving of life in mines, as well as the economical production of minerals. Since the Council did him the honour to elect him their President, six or seven years ago, the membership of the Institution had increased enormously, and he felt sure that if the Institution continued to increase it would conduce to the advantage of the country, and to the prosperity of all employed in mines, as well as to their happiness and safety.

The SECRETARY read the Annual Report of the Council as follows:—

THE INSTITUTION OF MINING ENGINEERS.

FOURTEENTH ANNUAL REPORT OF THE COUNCIL.

The six societies constituting The Institution of Mining Engineers are the same as last year, namely the Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The following table exhibits the progress of the membership since the formation of the Institution in 1889:—

Year ending July 31st.	No. of Members.	No. of Non-federated.	Totals.
1890	1,189	50	1,239
1891	1,187	9	1,196
1892	1,415	19	1,434
1893	1,533	19	1,552
1894	2,068	123	2,191
1895	2,210	109	2,319
1896	2,301	81	2,382
1897	2,447	60	2,507
1898	2,462	47	2,509
1899	2,445	41	2,486
1900	2,447	35	2,482
1901	2,524	30	2,554
1902	2,571	30	2,601
1903	2,662	26	2,688

At the invitation of the North of England Institute of Mining and Mechanical Engineers, which celebrated its jubilee on September 16th last, the Annual General Meeting of this Institution was held in Newcastle-upon-Tyne on September 17th, 18th and 19th, 1902. The London meeting was held on July 2nd, 3rd and 4th, 1903. Both of these meetings secured the attendance of a large number of members. The thanks of the Institution have been sent to the gentlemen who kindly opened their collieries, works, etc., to the members attending these meetings.

Mr. Robert McLaren has been elected an Honorary Member of the Institution.

Prizes have been awarded to the writers of the following papers, which are printed in the *Transactions* (vols. xx., xxi., xxii. and xxiii.):—

"Working Coal under the River Hunter, the Pacific and its Tidal Waters, near Newcastle, in the State of New South Wales." By Mr. A. A. Atkinson.

"The Carboniferous Limestone Coal-fields of West Lothian," and "The Oilshale-fields of the Lothians." By Mr. Henry M. Cadell.

"The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field." By Mr. John Cadman.

"An Experimental Gallery for Testing Life-saving Apparatus," and "The Application of Coal-cutting Machines to Deep Mining." By Mr. W. E. Garforth.

"The Theory of the Equivalent Orifice treated Graphically," and "An Extension of the Equivalent-orifice Theory." By Mr. H. W. G. Halbaum.

"The Coal-fields of Cooke Inlet, Alaska, U.S.A., and the Pacific Coast." By Mr. John Kirsopp, Jun.

"The Geological Features of the Somerset and Bristol Coal-field, with Special Reference to the Physical Geology of the Somerset Basin." By Mr. James McMurtrie.

"Alternating Currents, and their possible Application to Mining Operations. Part I.: What an Alternating Current is." By Mr. Sydney F. Walker.

Addresses have been delivered during the year by Mr. H. B. Nash, president of the Midland Institute of Mining, Civil and Mechanical Engineers; by Sir Lindsay Wood, Bart., president of the North of England Institute of Mining and Mechanical Engineers; by Mr. A. M. Henshaw, president of the North Staffordshire Institute of Mining and Mechanical Engineers; and by Mr. T. J. Davies, president of the South Staffordshire and East Worcestershire Institute of Mining Engineers.

The papers published in the *Transactions* during the past year have been of a varied character and the high standard of the proceedings has been maintained. The Council trust that the members will contribute papers in the future as liberally as in the past.

The papers on geology include the following:—

"The Use of Carboniferous Plants as Zonal Indices." By Mr. E. A. Newell Arber.

"Notes on the Gold Coast of West Africa." By Mr. Louis P. Bowler.

"Notes on the Correlation of the Beds of the Carboniferous Series in the North-east and North-west of England." By Mr. David Burns.

"The Gypsum of the Eden Valley." By Mr. David Burns.
"Undersea Coal of the Northumberland Coast." By Mr. T. E. Forster.
"Some Silver-bearing Veins of Mexico." By Mr. Edward Halse.
"The Marl-slate and Yellow Sands of Northumberland and Durham." By Prof. G. A. Lebour.
"The Occurrence of Gold in Great Britain and Ireland." By Mr. J. Malcolm Maclaren.
"Underground Temperatures." By Mr. F. G. Meachem.
"Luxemburg and its Iron-ore Deposits." By Mr. J. Walter Pearse.
"The Geology of the English Lake District." By Mr. J. Postlethwaite.
"Further Remarks on the Portuguese Manica Gold-field." By Mr. A. R. Sawyer.
"Mineral Resources of the State of Rio Grande do Sul, Brazil." By Mr. H. Kilburn Scott.
"The Probability of finding Workable Seams of Coal in the Carboniferous Limestone or Bernician Formation, beneath the Regular Coal-measures of Northumberland and Durham, with an Account of a recent Deep Boring, made in Chopwell Woods, below the Brockwell Seam." By Mr. J. B. Simpson.
"Notes on the Map and Sheet-memoir of the North Staffordshire Coal-field, recently published by the Geological Survey of Great Britain." By Mr. J. T. Stobbs.

Mining engineering has been the subject of the following papers:—

"Working a Thick Coal-seam in Bengal, India." By Mr. Thomas Adamson.
"Sinking by the Freezing Method at Washington, County Durham." By Mr. Mark Ford.
"Undersea Coal of the Northumberland Coast." By Mr. T. E. Forster.
"Sherwood Colliery." By Mr. J. W. Fryar.
"Underground Fires." By Mr. F. W. Hardwick.
"Sinking of the Rhein-Preussen Colliery, Nos. IV. and V. Shafts." By Mr. W. H. Hepplewhite, H.M. Inspector of Mines.
"Douglas Colliery." By Mr. Douglas Jackson.
"The Re-development of the Slate-trade in Ireland." By Mr. G. H. Kinahan.
"The Occurrence of Gold in Great Britain and Ireland." By Mr. J. Malcolm Maclaren.
"Sinking on the Seashore at Musselburgh." By Mr. Robert Martin.
"Underground Temperatures." By Mr. F. G. Meachem.
"Mining in Manchuria." By Mr. W. A. Moller.
"The Re-opening of Hartley Colliery." By Mr. R. E. Ornsby.
"Notes on Systematic Timbering." By Mr. W. H. Pickering, H.M. Inspector of Mines.
"Hæmatite-deposits and Hæmatite-mining in West Cumberland." By Mr. W. E. Walker.

The following papers have been contributed on mechanical engineering at mines:—

"Pneumatic and Electric Locomotives in and about Coal-mines." By Mr. A. S. E. Ackermann.
"Four Old Labour-saving Ideas." By Mr. Henry Aitken.
"The Riedler Pump." By Mr. H. D. D. Barman.
"Improved Offtake-socket for Coupling and Uncoupling Hauling-ropes." By Mr. W. C. Blackett.
"Experiments on an Auxiliary Ventilating Fan." By Mr. M. Walton Brown.
"Ratchet and other Hand-machine Drills in the Cleveland Mines." By Mr. William Charlton.
"Central Condensing-plants for Collieries." By Mr. J. Duncan Crighton.
"Garesfield Railway and Incline." By Mr. J. R. Gilchrist.
"The Common-sense Doctrine of Furnace-draught." By Mr. H. W. G. Halbaum.
"The Electrical Driving of Winding-gears." By Mr. F. Hird.
"Air-compression by Water-power: The Installation at the Belmont Gold-mine." By Mr. D. G. Kerr.
"Steam-generation by the Gases from Beehive Coke-ovens." By Mr. M. R. Kirby.
"Improved Railway-rail Fastener." By Mr. Philip Kirkup.
"Coal-shipping." By Mr. John Kirsopp, Jun.
"Corliss-engined Fan at Seghill Colliery." By Mr. C. C. Leach.
"Superheated Steam at Seghill Colliery." By Mr. C. C. Leach.
"Some of the Considerations affecting the Choice of Pumping Machinery." By Messrs. A. H. Meysey-Thompson and H. Lupton.
"Apparatus for Controlling Railway-wagons while loading at Colliery-screens." By Mr. J. D. Miller.
"The Utilization of Exhaust-steam by the Combined Application of Steam-accumulators and Condensing Turbines." By Prof. A. Rateau.
"Stuffing-boxes dispensed with on Engines and Pumps." By Mr. Andrew Watson.
"Condensing-plant for Winding-engines." By Mr. Benjamin Woodworth.

The papers on mine-ventilation include:—

"Experiments on an Auxiliary Ventilating Fan." By Mr. M. Walton Brown.
"Corliss-engined Fan at Seghill Colliery." By Mr. C. C. Leach.

The following papers have been written on the treatment of ores, metallurgy, etc.:—

"Description of the Lead-ore Washing-plant at the Greenside Mines, Patterdale." By Mr. Wm. H. Borlase.
"Calcination of Blackband Ironstone at Dumbreck." By Mr. Mark Brand.
"Treatment of Low-grade Copper-ores." By Dr. Edward Dyer Peters.
"The Smelters of British Columbia." By Mr. W. Denham Verschoyle.

The applications of electricity have been discussed in the following papers:—

"Pneumatic and Electric Locomotives in and about Coal-mines." By Mr. A. S. E. Ackermann.
"A Magnetic Unlocking and Electrically-ignited Safety-lamp." By Mr. W. Best.
"Electrical Plant-failures, their Origin and Prevention." By Mr. A. C. Cormack.
"The Electrical Driving of Winding-gears." By Mr. F. Hird.
"Electrical Coal-cutting Machines." By Mr. Fredk. W. Hurd.
"The Max Electric Mining Lamp." By Mr. E. Roubier.
"Electric-power Distribution by Continuous Current, for Mining and General Purposes in North Wales." By Mr. T. P. Osborne Yale.

The following papers have been contributed on safety-lamps:—

"The Gray Type of Safety-lamp." By Mr. James Ashworth.
"A Magnetic Unlocking and Electrically-ignited Safety-lamp." By Mr. W. Best.
"The Max Electric Mining Lamp." By Mr. E. Roubier.

The question of coal-cutting has been discussed in the following paper:—

"Electrical Coal-cutting Machines." By Mr. Fredk. W. Hurd.

The training of colliery-managers and mining engineers has been discussed in the following papers:—

"The Technical Instruction of Working Miners, with suggestions as to Mine-managers' Examinations." By Mr. Alexander Forbes.
"The Training of a Mining-engineer." By Mr. R. A. S. Redmayne.

Mine-surveying and instruments have been treated of in the following papers:—

"A Measuring-tape, and its Use in Mine-surveying." By Mr. S. J. Pollitzer.
"The Underlay-table." By Mr. S. J. Pollitzer.

The following paper describing a mine-explosion has conduced to a lengthy and valuable discussion:—

"The Fernie Explosion." By Mr. W. Blakemore.

The miscellaneous papers comprize:—

"The Gases enclosed in Coal and Coal-dust." By Dr. P. Phillips Bedson.
"Underground Stables." By Mr. W. C. Blackett.
"Granite-quarrying, Sett-making and Crushing; and the Manufacture of Concrete-flags and Granitic Tiles." By Mr. Geo. H. Bragg.
"The Gases enclosed in Coal." By Dr. Broockmann.

"Barometer, Thermometer, etc., Readings for the Year 1902." By Mr. M. Walton Brown.

"Report of the Delegate of The Institution of Mining Engineers to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Belfast, September, 1902." By Mr. M. Walton Brown.

"The Crumlin Meteorite." By Principal H. Palin Gurney.

"Miners' Anæmia or Ankylostomiasis." By Dr. J. S. Haldane.

"Underground Fires." By Mr. F. W. Hardwick.

"The Re-development of the Slate-trade in Ireland." By Mr. G. [redacted]. Kinahan.

"Ambulance-instruction at Mines." By Mr. William Leck, H.M. Inspector of Mines.

"Underground Temperatures." By Mr. F. G. Meachem.

"Report of the Delegate of the North of England Institute of Mining and Mechanical Engineers to the Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, Belfast, September, 1902." By Mr. J. H. Merivale.

"The Alston Mines." By the Rev. W. Nall.

"The Valuation of Gas-coals." By Mr. James Stewart.

The preceding list, comprizing 79 papers, demonstrates the varied nature of the subjects printed in the *Transactions* (vols. xxiii. and xxiv.) during the past year.

"Notes of Papers (120) on the Working of Mines, Metallurgy, etc., from the Transactions of Colonial and Foreign Societies and Colonial and Foreign Publications" have been continued and should prove of value to the members.

Members can purchase, at privileged prices, copies of the *Transactions* of the following Corresponding Societies:—

The Australasian Institute of Mining Engineers.
The Canadian Mining Institute.
The Institution of Mining and Metallurgy.
The Mining Society of Nova Scotia.

Mr. M. Walton Brown represented the Institution at the meetings of the Corresponding Societies Committee of the British Association for the Advancement of Science, held at Belfast, in September, 1902; and Mr. John Gerrard and Mr. John Nevin at the Bradford Congress of the Sanitary Institute.

The Council regret that the proposal for the formation of a Benevolent Fund in connection with the Institution has fallen through, owing to lack of support on the part of the members; and all subscriptions and donations have been returned to the donors.

Dr.

	No. of Members. Federated.	No. of Members. Non-Federated.	Balance due at the beginning of the year.	Amounts falling due during the Year. Calls made during the year.	Excerpts.	Transactions, etc.	Totals.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Midland Counties Institution of Engineers	311	...	15 4 0	295 9 0	0 19 8	10 11 10	322 4 6
Midland Institute of Mining, Civil and Mechanical Engineers	302	...	6 13 0	286 18 0	5 16 9	4 6 8	303 14 5
Mining Institute of Scotland	440	26	11 8 0	431 0 0	17 3 2	4 6 8	463 17 10
North of England Institute of Mining and Mechanical Engineers	1,290	...	72 7 0	1,225 10 0	45 10 7	38 14 8	1,382 2 3
North Staffordshire Institute of Mining and Mechanical Engineers	206	...	20 10 8	195 14 0	6 16 11	5 6 8	228 8 3
South Staffordshire and East Worcestershire Institute of Mining Engineers...	96	...	70 14 10	91 4 0	2 0 0	11 6 8	175 5 6
Totals	2,645	26	196 17 6	2,525 15 0	78 7 1	74 13 2	2,875 12 9

Cr.

	Amounts Paid during the Year. Balance from previous year.	Calls.	Excerpts.	Transactions, etc.	Totals.	Balance due at July 31st, 1903.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Midland Counties Institution of Engineers	15 4 0	275 10 0	0 19 8	9 11 10	301 5 6	20 19 0
Midland Institute of Mining, Civil and Mechanical Engineers	6 13 0	285 0 0	5 5 0	3 6 8	300 4 8	3 9 9
Mining Institute of Scotland	11 8 0	426 15 0	17 3 2	1 0 0	456 6 2	7 11 8
North of England Institute of Mining and Mechanical Engineers	72 7 0	1,165 13 0	37 0 4	35 14 8	1,310 15 0	71 7 3
North Staffordshire Institute of Mining and Mechanical Engineers	13 17 8	178 12 0	1 10 0	2 0 0	195 19 8	32 8 7
South Staffordshire and East Worcestershire Institute of Mining Engineers	70 14 10	76 19 0	2 0 0	1 0 0	150 13 10	24 11 8
Totals	190 4 6	2,408 9 0	63 18 2	52 13 2	2,715 4 10	160 7 11

Dr. THE TREASURERS IN ACCOUNT WITH FOR THE YEAR

	£ s. d.	£ s. d.
July 31, 1902.		
To Balance at Bank, Current Account	487 11 1	
„ „ „ Deposit Account	1,544 18 5	
„ „ in Cashier's hands...	50 6 1	
		2,082 15 7
To Subscriptions for the Year ending July 31, 1901—		
Federated—		
South Staffordshire and East Worcestershire Institute of Mining Engineers		15 4 0
To Subscriptions for the Year ending July 31, 1902—		
Federated—		
Midland Counties Institution of Engineers	15 4 0	
Midland Institute of Mining, Civil and Mechanical Engineers	6 13 0	
Mining Institute of Scotland	11 8 0	
North of England Institute of Mining and Mechanical Engineers	69 7 0	
North Staffordshire Institute of Mining and Mechanical Engineers	8 11 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	48 9 0	
		159 12 0
To Subscriptions for the Year ending July 31, 1903—		
Federated—		
Midland Counties Institution of Engineers	275 10 0	
Midland Institute of Mining, Civil and Mechanical Engineers	285 0 0	
Mining Institute of Scotland	414 5 0	
North of England Institute of Mining and Mechanical Engineers	1,165 13 0	
North Staffordshire Institute of Mining and Mechanical Engineers	178 12 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	76 19 0	
		2,395 19 0
Non-Federated—		
Mining Institute of Scotland		12 10 0
Carried forward		£4,666 0 7

THE INSTITUTION OF MINING ENGINEERS. Cr.
ENDING JULY 31, 1903.

July 31, 1903.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
By Printing—				
Transactions, vol. xx., printing ...120 9 4				
„ „ „ plates ... 11 1 6				
		131 10 10		
„ „ xxi., printing ...249 14 10				
„ „ „ plates ... 74 15 8				
		324 10 6		
„ „ xxii., printing ...210 3 0				
„ „ „ plates ... 56 15 6				
		266 18 6		
„ „ xxiii., printing .. 496 19 4				
„ „ „ plates ...229 14 3				
		726 13 7		
„ „ xxiv., printing ...367 2 7				
„ „ „ plates ... 97 18 9				
		465 1 4		
„ „ xxv., printing ...185 6 6				
„ „ „ plates ... 71 0 6				
		256 7 0		
„ „ xxvi., plates ... 0 5 0		0 5 0		
			2,171 6 9	
Excerpts, vol. xii.		1 8 0		
„ „ xxi.		13 5 0		
„ „ xxii.		38 10 8		
„ „ xxiii.		40 15 10		
„ „ xxiv.		49 1 2		
„ „ xxv.		20 15 4		
			163 16 0	
Proofs of Papers for General Meetings			34 0 7	
Circulars			7 10 11	
				2,376 14 3
„ Addressing *Transactions*, etc.			60 15 7	
„ Stamps—Circulars		18 1 5		
„ „ Correspondence . .		22 2 11		
„ „ *Transactions*		407 13 1		
			447 17 5	
„ Stationery, etc.			26 19 2	
„ Insurance of *Transactions*			3 0 0	
„ Binding—Library		1 5 0		
„ „ Sundries...		0 17 6		
„ „ *Transactions*		27 15 6		
			29 18 0	
Carried forward			£568 10 2	£2,376 14 3

Dr. THE TREASURERS IN ACCOUNT WITH

	£ s. d.	£ s. d.	£ s. d.
Brought forward			4,666 0 7
To Local Publications and Authors' Copies—	1901-1902.	1902-1903.	
The Institution of Mining Engineers	0 0 0	36 8 2	
Midland Counties Institution of Engineers ...	0 0 0	0 19 8	
Midland Institute of Mining, Civil and Mechanical Engineers	0 0 0	5 5 0	
Mining Institute of Scotland	0 0 0	17 3 2	
North of England Institute of Mining and Mechanical Engineers	0 0 0	37 0 4	
North Staffordshire Institute of Mining and Mechanical Engineers	0 0 0	1 10 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	0 15 2	2 0 0	
	0 15 2	100 6 4	101 1 6
To Sales of Transactions, etc.—	1901-1902.	1902-1903.	
The Institution of Mining Engineers	3 11 6	209 5 3	
Midland Counties Institution of Engineers ...	0 0 0	9 11 10	
Midland Institute of Mining, Civil and Mechanical Engineers	0 0 0	3 6 8	
Mining Institute of Scotland	0 0 0	1 0 0	
North of England Institute of Mining and Mechanical Engineers	3 0 0	35 14 8	
North Staffordshire Institute of Mining and Mechanical Engineers	5 6 8	2 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	6 6 8	1 0 0	
	18 4 10	261 18 5	280 3 3
To Advertizements			791 14 8
To Address Labels			7 0 0
To Interest on Deposit Account			38 18 6
			£5,884 18 6

THE INSTITUTION OF MINING ENGINEERS.—*Continued.* Cr.

	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward				568	10	2	2,376	14	3
By Reporting General Meetings				17	2	6			
„ Expenses of General Meetings				3	2	8			
„ Incidental Expenses				12	9	6			
„ Salaries, Wages, Auditing, etc.				718	18	0			
„ Indexing *Transactions*				35	18	0			
„ Travelling Expenses				17	9	7			
							1,373	10	5
„ Advertizement Commission				...		...	197	18	8
„ Translations of Papers				17	16	0			
„ Abstracts of Foreign Papers, vol. xxi. ...	15	16	1						
„ „ „ „ xxii. ...	33	4	9						
„ „ „ „ xxiii....	33	7	0						
				82	7	10			
„ Barometer Readings, etc.				9	2	0			
„ Calendars				13	13	6			
„ Prizes for Papers in Volumes xx., xxi., xxii., xxiii. ...				40	0	0			
							162	19	4
							4,111	2	8
„ Balance at Bank, Current Account				385	17	11			
„ „ „ Deposit Account				1,283	16	11			
„ „ in Cashier's hands				104	1	0			
							1,773	15	10
							£5,884	18	6

We have examined the above account of receipts and payments, with the books and vouchers relating thereto, and certify that in our opinion it is correct.

JOHN G. BENSON & SONS,
Chartered Accountants.

Newcastle-upon-Tyne.
August 8th, 1903.

THE INSTITUTION OF
BALANCE SHEET.—

Liabilities.

July 31st. 1903.	£	s.	d.	£	s.	d.
Sundry Creditors—						
Advertizements paid in Advance	20	13	11			
Printing, etc.	1,050	0	0			
Postage of Transactions	210	0	0			
Abstracts of Foreign Papers in Volumes xxiv. and xxv.	140	0	0			
Barometer Readings	8	0	0			
Prizes for Papers in Volumes xxiv. and xxv.	40	0	0			
Indexing Volumes xxiii., xxiv. and xxv.	30	0	0			
Advertizement Commission, etc.	55	4	3			
				1,553	18	2
Balance of Assets over Liabilities, exclusive of Value of Stock of *Transactions*, etc.				621	16	4

We have examined the above Balance Sheet, with the books and vouchers relating thereto, and certify that in our opinion it exhibits a correct view of the affairs of the Institution.

JOHN G. BENSON & SONS,
Chartered Accountants.

Newcastle-upon-Tyne.
January 19th. 1904.

£2,175 14 6

MINING ENGINEERS.
JULY 31, 1903.

Assets.

July 31st, 1903.	£ s. d.	£ s. d.
Balance at Bank, Current Account	385 17 11	
„ „ Deposit Account	1,283 16 11	
„ in Cashier's hands	104 1 0	
		1,773 15 10
Subscriptions for the Year ending July 31, 1902, Unpaid—		
Federated—		
North Staffordshire Institute of Mining and Mechanical Engineers	.....	6 13 0
Subscriptions for the Year ending July 31, 1903, Unpaid—		
Federated—		
Midland Counties Institution of Engineers	19 19 0	
Midland Institute of Mining, Civil and Mechanical Engineers	1 18 0	
Mining Institute of Scotland	4 5 0	
North of England Institute of Mining and Mechanical Engineers	59 17 0	
North Staffordshire Institute of Mining and Mechanical Engineers	17 2 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	14 5 0	
		117 6 0
Local Publications and Authors' Copies, Unpaid—		
Midland Institute of Mining, Civil and Mechanical Engineers	0 11 9	
North of England Institute of Mining and Mechanical Engineers	8 10 3	
North Staffordshire Institute of Mining and Mechanical Engineers	5 6 11	
		14 8 11
Transactions Sold, Unpaid—		
Midland Counties Institution of Engineers	1 0 0	
Midland Institute of Mining, Civil and Mechanical Engineers	1 0 0	
Mining Institute of Scotland	3 6 8	
North of England Institute of Mining and Mechanical Engineers	3 0 0	
North Staffordshire Institute of Mining and Mechanical Engineers	3 6 8	
South Staffordshire and East Worcestershire Institute of Mining Engineers	10 6 8	
		22 0 0
Advertizements, Unpaid		241 10 9
		£2,175 14 6

BOOKS, ETC., ADDED TO THE LIBRARY.

African Review, London. Vol. xxxii., Nos. 512-514; vol. xxxiii., Nos. 515-527; vol. xxxiv., Nos. 528-540; vol. xxxv., Nos. 541-553; and vol. xxxvi., Nos. 554-563.

Annales des Mines de Belgique, Bruxelles. Vol. vii., No. 4; and vol. viii., Nos. 1-3.

Australasian Institute of Mining Engineers, Melbourne. Transactions, vol. viii., No. 2; and vol. ix., No. 1.

British Association for the Advancement of Science, London. Report of the Seventy-second Meeting, held at Belfast, in September, 1902. Demy octavo, cxviii., 924 and 112 pages.

British Society of Mining Students, Medomsley. Journal, vol. xxiv., Index; and vol. xxv., Nos. 1-6.

Canadian Mining Institute, Montreal. Journal, vol. v.

Chemical and Metallurgical Society of South Africa, Johannesburg. Journal, vol. iii., Nos. 3-14; and vol. iv., No. 1.

Cory Brothers & Company, Limited, Cardiff. British Coal and Freight Circular and General Export List, August 31st, 1902, to July 31st, 1903.

Cuerpo de Ingenieros de Minas del Perú, Lima. Boletín, Nos. 1 and 2.

Engineering and Mining Journal, New York City. Vol. lxxiv., Nos. 9-26; vol. lxxv., Nos. 1-26; and vol. lxxvi., Nos. 1-8.

Engineering Times, London. Vol. viii., Nos. 4-6; vol. ix., Nos. 1-6; and vol. x., Nos. 1 and 2.

Franklin Institute of the State of Pennsylvania, Philadelphia. Journal, vol. cliv., Nos. 3-6; vol. clv., Nos. 1-6; and vol. clvi., Nos. 1 and 2.

Geological Institution of the University of Upsala, Upsala. Bulletin, vol. v., No. 10.

Institution of Mining and Metallurgy, London. Transactions, vol. x.

Manchester Geological Society, Manchester. Transactions, vol. xxvii., Nos. 10-17; and vol. xxviii., Nos. 1-7.

Massachusetts Institute of Technology, Society of Arts, Boston. Technology Quarterly, vol. xv., No. 4; and vol. xvi., Nos. 1 and 2.

Mining Society of Nova Scotia, Halifax. Journal, vols. vi. and vii.

New South Wales, Department of Mines, Sydney. Annual Report, 1901 and 1902.

New Zealand, Department of Mines, Wellington. Annual Report, 1902.

Queensland, Department of Mines, Brisbane. Annual Report, 1902.

—, Geological Survey, Brisbane. The Sapphire Fields of Anakie. By B. Dunstan. Foolscap folio, 26 pages and 14 plates.

Queensland Government Mining Journal, Brisbane. Vol. iii., Nos. 26-31; and vol. iv., Nos. 32-37.

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EXCHANGES.

Annales des Mines de Belgique.
Australasian Institute of Mining Engineers.
British Association for the Advancement of Science.
British Society of Mining Students.
Canadian Mining Institute.
Chemical and Metallurgical Society of South Africa.
Franklin Institute of the State of Pennsylvania, U.S.A.
Geological Institution of the University of Upsala, Sweden.
*Institution of Mechanical Engineers.
Institution of Mining and Metallurgy.
*Lake Superior Mining Institute.
Manchester Geological Society.
Massachusetts Institute of Technology.
Mining Society of Nova Scotia, Canada.
*Natal, Geological Survey of the Colony of.
New South Wales, Department of Mines and Agriculture, Geological Survey.
*Revue Universelle des Mines, de la Métallurgie, etc.
South Wales Institute of Engineers.
*Transvaal, Department of the Mining Commissioner.
United States Geological Survey.

* No publications received during current year.

July 31st, 1903.

The meeting then divided into two sections for the reading and discussion of papers. The President (Mr. J. C. Cadman) presided over one section, and the retiring-President (Sir Lindsay Wood, Bart.) over the second section of the members.

Mr. W. Walker read the following paper on "Electric Coal-cutting":—

ELECTRIC COAL-CUTTING.

By W. WALKER.

Introduction.—Many papers have been written during the past few years on coal-cutting machines, and, therefore, the writer of these notes does not intend traversing the same ground again; except, where it may be necessary, to support any argument for or against coal-cutting by machinery. Probably all mining engineers would readily admit that coal-cutting machinery could not be profitably applied to all coal-seams at present being worked, for one or other of the following reasons:—(1) Seams so easily wrought that only a small charter-price per ton is paid; (2) seams intersected by numerous faults of various throws; (3) seams nearly exhausted; (4) seams worked by the bord-and-pillar system; and (5) seams exceeding 6 feet in thickness and having a bad roof.

In such seams, in the writer's opinion, it would be a waste of money and time to introduce coal-cutting machinery; the experiment would be costly, and the result would be failure. However, the large outputs of to-day are rapidly exhausting the thick and easily wrought seams, and the bord-and-pillar system could in many cases be converted into the longwall method of working, which affords the best results from coal-cutting machinery.

There are also numerous old collieries, where the use of coal-cutting machines would have saved fortunes, had it been possible to have introduced them when the collieries were in their infancy; but, having worked 20 to 30 years on a comparatively small area which cannot now be increased, the workings are now at a considerable distance from the pit, and are probably cut up into isolated districts, which in the course of a few years would be worked out to the boundary. The application of coal-cutting machinery at these collieries would necessitate a considerable outlay of money on plant, which would

never be redeemed, and consequently these collieries are compelled to struggle for existence in this competitive period, and be content if they can make both ends meet.

Coal-cutting by machinery is developing slowly at present, but, in the near future, it will become an urgent necessity, and the writer is of opinion that the introduction of coal-cutting machines might be an advantage at certain collieries under the following conditions:—(1) New collieries with thin seams, that is, 3 feet thick and under, with a fair roof and hard or soft holing; (2) old collieries commencing the working of new seams, with a fair roof and hard or soft holing; and (3) collieries with an ample area of unworked coal, where the holing is hard, and it is difficult to get it done by hand at a price consistent with the market-value of the coal. It is well known that hard holing is much more difficult to effect than to direct special attention to a bad roof, and every year there is a reduction of the number of workmen willing to continue as holers, where the holing is hard. The soft or hard nature of the floor of any seam could be easily recognized from a table carefully compiled, so as to shew the number of holers employed, the number of days worked, and the daily output.

The tendency of workmen is to work less time, and to maintain the same wage, and if this cannot be done in one mine, they flock in large numbers to new collieries with thick seams and good holing, thereby creating a scarcity of workmen at the collieries which are working thin seams with hard holing. Coal-holing machines are thus becoming a necessity in thin seams, with hard or moderately hard holing. The young colliers of to-day are not trained to hard work, as were their fathers, and, evidently, they do not intend to be so trained.

New London Colliery.—The writer's experience of electric coal-cutters is not extensive, but it has been varied, comprizing failure on one hand, and success on the other. The Scott-and-Mountain machine was tried at the New London Colliery of the Digby Colliery Company, Limited. This disc or wheel-machine, designed to do hard work, was commenced in the Deep Hard seam, which is about 2 feet 9 inches thick, with a good bind roof, and a hard fire-clay floor. The face rose at an angle of 1 in 9. The floor contains ironstone-balls from 1 inch to 3

inches in diameter, lying more or less in pockets; therefore the machine would go fairly well for a time, but on coming into contact with the ironstone-balls, the cutters were rapidly "stumped," or some part or other of the machine was broken. The machine was guaranteed to cut in the floor at the rate of 60 yards, 5 feet under, in 9 hours. The distance cut per shift varied very considerably, sometimes it cut 8 or 10 yards, then 20 or 30 yards, and on one occasion it cut 70 yards, but a portion of this length was cut in the coal, and the average distance was about 20 yards per shift. The cost of taking up the floor behind the machine was sometimes great, owing to the machine-cut rising up into the coal. The output of coal was very varied from this district, owing to the short length of the cuts and the breakdowns. It could cut coal at a rapid rate, and had the thickness of the coal been such as to enable this to be done, or the quality inferior, it could easily have cut a distance of 100 yards in 9 hours. The use of this machine was abandoned, after an exhaustive trial. The number of men required to work this machine were as follow:—2 road-layers, 1 driver, 1 man shovelling-out dirt at the cutting wheel, 1 man timbering and spragging, and 1 man cleaning out the holing dirt. In addition to these 6 men, there was a representative of the manufacturers of the machine, and had it been successful, an extra man would have been required to assist in cleaning out the holing dirt.

It was next decided to try the Hurd large bar-machine on the same coal-face, 300 yards long, a distance which was afterwards reduced to 100 yards. The machine was guaranteed to cut 50 yards, 5 feet under, in 9 hours. It acted somewhat similarly to the Scott-and-Mountain machine, and after cutting a few webs, a length of 6 inches was cut off the bar, with the object of assisting the machine; but frequent breakdowns and short distances cut caused a variable output, and after a short trial it was abandoned. The number of men required to work this machine was as follows:—2 road-layers, 1 driver, 1 man shovelling-out dirt at the sleeve, 1 man timbering and spragging, and 1 man cleaning out the holing dirt. In addition to these 6 men, there was an electrician, and frequently his assistant. If this machine had been successful, one more cleaner-out would have been necessary. The last breakdown happened while Mr.

Hurd was with the machine, and induced him to devise an arrangement to prevent the machine from racing when not cutting.

It is the writer's firm opinion that there is no machine in the market that could be successfully applied to this seam as then worked. The working-face was end-on while the machines were being tried, afterwards it was turned face-on, it is now hand-holed, and no particular difficulty is experienced in securing men to work in this district.

Digby Colliery.—The opening out of the Tupton, Low Main, or Furnace coal-seam at the Digby colliery, belonging to the same firm, suggested once more the trial of an electric coal-cutter. This seam of coal is noted in the Erewash valley for its hard holing, yet its nature varies very considerably in different parts of the valley. Sometimes, there is a point-pricking, just under the coal, in which the holer can work with comparative ease; again, the floor in some places is quickly affected by water, and the holing is done by going through it gradually, and pulling off slabs that have been affected by the water; but, at the Digby colliery, neither of these conditions are found, and the coal sits dead on the bats, which are about 5 inches thick, dark in colour, and of a hard "crapley" nature. Below the bats is an impure fire-clay, very hard and compact, and in the upper portion of this fire-clay the seam was holed, as it was found that the upper 4 to 6 inches of this dirt was practically free from ironstone-balls. The section (Fig. 1, Plate IX.) is as follows:—

		Ft.	In.	Ft.	In.
Roof:	Bind, good	–		—	
Seam:	**COAL**	2	10		
	Bats	0	4½		
Holing:	Fire-clay	0	4½		
				3	7
Thill:	Fire-clay, mixed with ironstone-balls	0	5		

The seam is worked end-on, and the dip of the face, which is practically the dip of the seam, is 1 in 9. A pick-point was seldom broken during hand-holing, but there was a gradual wearing-away of the point; yet the holing was so hard and compact that 6 out of every 10 men who were sent into this district as holers would refuse to work a second shift, and

frequently holers failed to complete one stint, that is 6 feet long by 4 feet deep per shift. Therefore, in order to open out this seam, it was necessary to draw some of the best and most reliable men from other seams, and to the credit of these men they remained until the coal-cutting machine was started. As the weight came upon the face, the holing improved a little, but not much, and the greatest length ever holed for 6 days of work was 18 yards, 4 feet under, and this was only performed on two occasions; although every suggestion was tried that was at all likely to assist the holing.

After careful consideration, it was decided to try a specially built Hurd machine to hole in the Tupton seam.

The electric-power plant comprizes a Scott-and-Mountain dynamo of 400 volts and 180 ampères. It is erected at the New London colliery, which is about $\frac{3}{4}$ mile in a straight line from the Digby colliery, and, for certain reasons, it was decided to place the cables underground.

The only cables left in their original positions after completing the trials of the two coal-cutting machines previously referred to, were the shaft-cables, which are enclosed in pipes, $2\frac{3}{4}$ inches in diameter, and hermetically sealed at the surface. The other cables had, meanwhile, been used for electric pumping and lighting purposes, and consequently it became necessary to buy new main cables. A Callender insulated, vulcanized bitumen-cable, with 19 wires of No. 14 wire-gauge was connected to the shaft-cables, and carried along the underground-road to Digby colliery, being fixed by means of tarry string to the props and bars in the road-way; and, for safety, on opposite sides. The cables were carried down to No. 5 gateway, and connected to the face-cables and gateway-cables, used with previous machines (Fig. 2, Plate IX.).

On March 25th, 1903, the Hurd coal-cutting machine was taken to the power-plant at New London colliery, and run empty for a short time, after which it was sent down the Digby Shaft, and arrived at the point of cutting on March 31st, 1903. The length of the face upon which the machine was to work is 170 yards, with gateways 40 yards apart (Fig. 3, Plate IX.).

The writer had suggested, at the time when the machine was ordered, that a $4\frac{1}{2}$ feet bar should be used at first, and as the

men became accustomed to the machine and to its working, that 5 feet and 5½ feet bars should be introduced; cutting-bars, 4½ feet long, were supposed to be sent, but on arrival their lengths were found to be 4 feet 0¼ inch, and 4 feet 3½ inches respectively. (This mistake was annoying, but no blame could be attached to Mr. Hurd or Messrs. Mavor & Coulson.) However, the machine was commenced with the 4 feet 0¼ inch bar: this being the correctly threaded bar to use when cutting to the rise. During the first two cuts much difficulty was experienced in the laying of the roads, chiefly due to the uneven floor, common in mines, where the floor is made and not natural; and there were several stoppages, so as to pick off projecting pieces of coal and dirt. As the machine advanced, it was found that the working-face towards the top-end was not straight, a most important matter in the operation of coal-cutting machines. On arriving at the top-end, the machine was turned: this is a much longer and more expensive operation than usually represented, but it had been anticipated, owing to previous experience of turning coal-cutting machines. The machine then commenced to cut to the dip, with the 4 feet 3½ inches bar, it being arranged to run out at the bend of the face, and to turn again. On cutting to the dip, the same difficulty was experienced as with previous machines namely:— It did not cut so freely, nor cut so much yardage to the dip as it did to the rise. On reaching the bend, the machine was run out and turned again, and cut into the top-end of No. 5 stall; and the machine was then turned again, so as to cut down hill. It was then decided to flit the machine in future, when it reached the top-end, for the following reasons: (1) The machine could not be turned and restarted until the coals last cut were all loaded out, and an advance hole had been made for the next cut. This delay made it impossible with the arrangements of the gateways to keep the machine at work, while, at the same time, the coal at the bottom-end of the district was all loaded out. (2) To avoid leaving so large an open space, unpacked, at each end of the face, in which to turn the machine, which is 9½ feet long, and weighs nearly 60 hundredweights. (3) Because the machine cuts better to the rise than to the dip, even when a drag is attached behind the machine. And (4) to obtain a fairly uniform daily output from the district.

Therefore, on its next arrival at the top-end, the machine

was run back to the gate-end, it was partly turned on the gate-end plate, and placed upon a very low but strong bogey: this was used because the road-gauge is 18 inches, whereas the gauge of the machine is 22 inches. The machine was taken round by the gate-roads, into the bottom-end of No. 8 stall and recommenced cutting to the rise. And thereafter a third rail was laid on the roads, to the gauge of the machine, so as to avoid the loading and unloading of it (with experienced men, 2 hours are required to load, and the same time to unload the machine); and it also avoids the risk of the machine toppling over. A third rail was also laid in No. 5 gateway, down the engine-plane and along No. 8 gateway. Table I. records the cost of (1) turning the machine, (2) flitting it by a bogey, and (3) running it on rails.

TABLE I.

Dates. 1903.	Length cut.	Cost per Yard of Holing.			Remarks.
		Turning.	Flitting by Bogey.	Flitting on Rails.	
	Yards.	Pence.	Pence.	Pence.	
April 15	155½	2·30	—	—	Full length of face, in which 1 yard equals 1 ton.
,, 20	57½	5·43	—	—	A short cut was made, so as to straighten the face.
,, 23	58	5·84	—	—	Do. do.
May 4	169	2·87	—	—	A fall of roof hindered the turning of the machine a little.
,, 10	163½	—	5·04	—	Put on the bogey: the men were unaccustomed to the work.
,, 15	164½	—	3·20	—	Put on the bogey.
,, 20	166	—	2·44	—	Do.
,, 27	164	—	—	2·74	Ran the machine on the rails, it was awkward at the turns.
June 4	168	—	—	2·78	Ran the machine on the rails, the machine was twice off the road, due to the new wheels coming off; the extreme part of each turn was laid out to 24½ inches gauge, and two special wheels 6 inches on the tread were used.
,, 10	168	—	—	2·71	Machine got better round the turns.
,, 15	172	—	—	2·80	Machine went off the road owing to a twisted rail.
,, 20	175	—	—	2·68	No difficulty.
,, 25	173	—	—	2·24	The record time: the flitting from No. 5 stall to the gate-end of No. 8 stall only occupied 2 hours 45 minutes.

Meanwhile, the 4½ feet cutting-bars had arrived, and after one was tried, their use was abandoned for a time, owing to the thin end becoming very hot, and the cutters were worn down excessively within 18 inches from the extreme and thin end of the cutting-bar. This seemed unaccountable at first, but it was eventually found with a longer bar, that the machine had to be more highly tilted, and this caused the thin end of the bar to pass downward into the fire-clay, where a few ironstone-balls are found. The use of the 4 feet bar was again resumed, and no further trouble occurred with this bar or the cutters, so long as the driver kept the cut at one particular level; if he lets it rise, it passes into the bats, which wear off the cutters in 3 or 4 yards, and if it passes downward into the fire-clay with ironstone-balls, the same wear occurs; it is, therefore, of the utmost importance that one, and only one, level should be followed.

After cutting a few webs, successfully, with the short bar, the 4½ feet bar was tried again, but the machine ran sluggishly; and, in order to assist it, the blade of the cleaner-bar was removed, merely using the bar to keep the dirt loose. The cutting-speed was again increased, but, owing to the excessive amount of dirt left under the coal, the 4 feet bar was replaced, and the cleaner-bar rearranged.

The writer is of opinion that a 4 feet tapered bar is the longest that can be used successfully; for, if the nature of the floor be such as to enable a longer bar to be used, it is practically an impossibility to remove the dirt from the extreme end of the cutting, and if 2 or 3 inches of this material be left in, it will cause endless trouble to the loaders, and its removal would entail a considerable addition to the expense of cleaning.

The difficulty experienced with the 4½ feet bar suggested to the writer that a parallel bar should be used, and, if successful, it would remove several of the important disadvantages of the tapered bar, as follows:—(1) The periphery-speed of the thin end of a tapered bar is much less than at the larger end. For example, if the tapered bar makes 400 revolutions per minute, and the circumference over the cutters at each end of a 4 feet bar is 21 and 16½ inches respectively, the speed travelled per minute by the two ends is 700 and 550 feet respectively, or a difference of 27 per cent. (2) The hardest part of

holing, when done by a machine, is towards the extreme end of the cut. The front part is more or less, but always to an appreciable extent, affected by the weighting of the last web of coal, and by the action of air and moisture. This part is therefore more easily cut, but the extreme end always retains its original hardness; and consequently the periphery-speed of the cutter-bar at this point should be greater rather than less. (3) While the tapered bar cuts less dirt than a parallel bar would, yet the difficulty of removing the last 3 or 4 inches is great; whereas, with a parallel bar, this difficulty would be largely removed, and would thus tend to facilitate the falling of the coals.

Parallel Cutter-bar.—The writer therefore pointed out these difficulties to Messrs. Mavor & Coulson, suggesting that a parallel bar should be tried; and after further correspondence on this subject, a 4 feet parallel bar was made by them, but at the same time they expressed doubts as to it being workable. The weight of the 4 feet parallel bar is 2 cwts. 3 qrs. 17 lbs., and that of the 4 feet tapered bar is 2 cwts. 2 qrs. 1 lb., a difference of 1 qr. 16 lbs. This bar was sent down the pit on June 4th, and arrangements were made to try it on June 6th at 6 a.m. It was a good fit, and easily placed in position on the coal-cutting machine; but the shanks of the double cutters used at the extreme end of the bar were too long, and, therefore, could not be properly fastened. It was, however, started, and was found to take less power than the tapered bar; and, although only 3 yards were cut for the above reason, the men in charge were impressed by its steadiness and sweetness of cutting.

On Monday, June 8th, this bar was again tried, and proved a remarkable success, cutting a length of 57 yards in 2 hours 45 minutes, or at the rate of 20 yards per hour. The most remarkable part of its success was in the reduction of the power used; with the tapered bar, the average was about 50 ampères, but with the parallel bar the average was about 40 ampères, shewing a reduction of 10 ampères or 20 per cent. The whole machine ran extremely steadily, and reached the web of coal which was being loaded out at 12·15 a.m., having cut a length of 45 yards. It then stood until 3·15 a.m., when all the coals had been loaded; the road was then laid, the machine cut to the coals again, and, had the face been clear, a record cut would

been made. The cleaning-out was greatly improved, and arks of the cutters at the extreme end could be seen from) end of the night's cut. At 7:30 a.m., the coals (cut at 12·15 a.m.) were dropped for the loaders, with no trouble whatever.

The parallel bar is undoubtedly a great success, because:—It takes less power to drive it: a 4 feet tapered bar consumes 5,833 watts or 7·77 horsepower per square foot of area holed, while the 4 feet parallel bar only consumes 3,500 watts or 4·66 horsepower, a saving of about 40 per cent. (2) The machine cuts 20 per cent. more yardage, frequently working on the third-notch feed, whereas the tapered bar never exceeded the second-notch feed, which is equal to 15 yards per hour. And (3) the holing dirt, towards the extreme end, was not pulverized into dust, but chipped off into pieces about the size of a nut, and readily removed by the tapered trailer-bar to the sleeve: this being due to the increased speed of the extreme end of the bar.

The writer thought that this bar could be improved, and he has received a 4½ feet parallel bar, with cutter-holes sunk in the thread (Figs. 6 and 7). These holes are countersunk down, so that the heads of the cutters may enter them, thus supporting and strengthening the cutters. The

FIG. 6.—PARALLEL CUTTING-BAR, WITH CUTTERS ARRANGED ON THE THREAD.

FIG. 7.—PARALLEL CUTTING-BAR, WITH CUTTERS ARRANGED IN A SPIRAL.

s are arranged spirally and, by this special arrangement, more than three or four teeth can come into direct contact

with the holing at the same moment: and, therefore, less care is necessary in charging a bar with the cutters, so as to place them in a straight line.

Road-laying.—In many collieries, the road-laying is done by the men working the machine, during the shifts cutting, and this plan was adopted, although it is different from the arrangement previously adopted when coal-cutting; but it was recognized that the greatest proportion of time during the cutting shift was absorbed in road-laying, probably due to the exceptional hardness of the holing. The men working the machine have not time to pass over the rails during the time it is working, consequently the machine has to stand while the road is being laid, and so great is the strain on the rails that each rail has to be most carefully and securely spragged.

Rails were, then, supplied for the entire length of the working-face, in 9 feet lengths, weighing 29 pounds to the yard, and free from nails or fishplate-holes, and a man and a boy were appointed to lay the road for the coal-cutting machine. This work is done during the opposite shift to the cutting-shift, when possible, and is examined and reported upon at the close of each shift by a deputy who is well versed in machine road-laying. The work of road-laying at present is slow, owing to a scarcity of iron-sleepers to cover the full length of face, but when these sleepers are all received, probably one man will be able to lay the full length of road. The same rails are used for loading out the coals.

Road-laying for an undercutting bar-machine takes more time for a given length than for a wheel-machine, and then it is not so firm; this is due to the extra tilt that must invariably be given to the goaf-side rail, and the extra packing of this rail. It therefore lies less solid than if it were laid directly on the floor, and renders extra spragging essential. Thus, road-laying for a bar-machine in hard holing, where the machine tends to push itself outward, must be very carefully done.

Cutters.—The cost of cutters for the bar-machine, when made from the best steel at £2 12s. per cwt., 1 inch in diameter, is 5½d. each, including forging. The exact shape of the point can only be ascertained by experiment, as a point most suitable

for one seam may be quite unsuitable for another: the pick-point is found most suitable in this case. The cutters are first sharpened, put on one side to cool, reheated to a worm red, and afterwards dropped into the water to cool: this affords the best temper in their case.

In charging the tapered bar with cutters, too much care cannot be taken in order that all of them may be the same height above the bar, and the cutters should be so chosen that, when fixed, the points are practically in a straight line. If this alignment be carelessly done, the machine will work at a great disadvantage; and a few minutes occupied in the selection and arrangement of cutters is well spent. The usual time required to change the cutters of a bar-machine is about 1 hour, from starting to stopping; sometimes it may be done in less, and at other times it may take more than 1 hour. A variety of carefully made punches facilitates the changing of the cutters. The driver can tell, at once, when the cutters require changing by the reduced speed of the machine, and, if anxious to succeed, he will examine his cutters, and replace the blunt ones; and if he fails to do so, his time will be spent in replacing burnt-out fuses.

The total number of cutters supplied since the machine started is 268, the number of workable cutters counted on June 20th, 1903, is 232; and the number of cutters lost or scrapped is 36.

Position of Coal-face.—Where hand-holing is the practice, it is well known that the straighter the face, no matter on what line of point the face may be worked, the more easily the coals are won, that is, the more easy the holing becomes, the more ready are the coals to fall, and the less is the percentage of slack and small coal. It seldom happens that a coal-face is quite straight, greater or lesser irregularities are common, and these irregularities may move along the face of a district; but when a good workman finds that any crookedness of his working-face affects his work or output, he holes off an extra sline or web, gets his face into line, and is amply repaid for his trouble. The making of extra cuts, with a machine that requires turning, or flitting, is very expensive; therefore, the straighter the face prepared for a machine, the better will be its

TABLE II.—DETAILS OF THE WORKING OF

1903.	Length of Face ready for the Machine.	Length of Rails laid for the Machine.	Machinemen went down at	Machine commenced Cutting at	Machine finished Cutting at	Actual Time that the Machine was Cutting.	Distance cut.	Average Depth of the Undercut.	Distance Out in the Floor.	Distance Out in the Bats.	Distance Cut in the Coal.	Men Employed at the Machine.
	Yards.	Yards.	P.M.	H. M.	H. M.	H. M.	Yards.	Ft. In.	Yards.	Yards.	Yards.	
Mar. 31	49	None.	6 0	9 50	5 45	4 30	19	4 0	19	None.	None.	4
Apr. 1	29	,,	6 0	8 45	5 20	4 0	28	3 9	28	,,	,,	4
,, 2	30	,,	6 0	7 40	9 45	1 15	15	3 11	15	,,	,,	4
,, 3	36	,,	6 0	8 0	2 0	2 45	37	3 10	37	,,	,,	4
,, 6	—	—	—	—	—	—	—	—	—	—	—	—
,, 7	35	,,	6 0	8 10	4 50	3 40	25½	3 11	25½	,,	,,	4
,, 8	31	,,	6 0	7 50	2 45	3 0	31	3 10	31	,,	,,	4
,, 15	—	—	—	—	—	—	—	—	—	—	—	—
,, 16	130	,,	6 0	9 15	3 20	2 30	20	4 2	20	,,	,,	5
,, 17	130	,,	6 0	8 0	5 50	2 10	27½	3 10	27½	,,	,,	4
,, 20	20	,,	6 0	2 45	4 0	0 45	10	3 4	10	,,	,,	4
,, 21	34	,,	6 0	7 30	5 30	3 0	34	3 10	34	,,	,,	4
,, 22	14	,,	9 0	11 40	3 15	1 20	14	3 11	14	,,	,,	4
,, 23	13	,,	9 0	5 45	6 0	0 4	1	4 0	1	,,	,,	5
,, 24	42	,,	6 0	8 20	12 20	2 5	18	3 10	12	4	2	4
,, 26	130	,,	10 0	12 30	6 0	1 10	10	3 11	10	None.	None.	4
,, 27	120	,,	6 0	9 10	5 35	3 5	40	3 10	40	,,	,,	4
,, 28	95	,,	6 0	9 0	6 0	3 50	38	3 8	38	,,	,,	4
,, 29	50	,,	6 0	8 55	5 10	3 45	28	4 0	26	2	,,	4
,, 30	30	,,	9 0	10 40	5 0	2 45	26	4 0	26	None.	,,	4
May 1	6	,,	9 0	11 45	1 30	1 20	8	3 11	8	,,	,,	4
,, 4	21	,,	4 0	3 30	5 30	0 45	5½	3 10	3	2½	,,	6
,, 5	90	,,	9 0	12 35	5 0	1 50	26	4 0	26	None.	,,	4
,, 6	100	,,	6 0	8 5	5 10	3 30	50	3 10	50	,,	,,	5
,, 7	73	,,	6 0	8 0	5 30	3 40	50	3 10	50	,,	,,	5
,, 8	31	31	6 0	7 45	4 45	2 45	32	3 9	32	,,	,,	6
,, 10	—	—	—	—	—	—	—	—	—	—	—	8
,, 11	72	40	6 0	1 45	5 5	1 35	19	3 10	16	3	,,	6
,, 12	98	60	8 0	8 55	5 35	4 30	58	3 9	58	None.	,,	7
,, 13	84	35	9 0	11 45	5 15	2 40	47½	3 10	47½	,,	,,	7
,, 14	40	40	9 0	10 25	3 25	2 20	40	3 11	40	,,	,,	7
,, 15	17	17	6 0	5 40	5 55	0 15	3	4 4	3	,,	,,	7
,, 17	66	39	10 0	11 30	5 20	2 55	32	4 0	32	,,	,,	7
,, 18	78	41	9 0	10 15	5 30	4 10	61	3 10	61	,,	,,	7
,, 19	70	70	9 0	10 10	5 30	4 25	70	3 10	70	,,	,,	7
,, 20	—	—	—	—	—	—	—	—	—	—	—	7
,, 21	60	22	9 0	11 45	5 30	3 20	31	4 4	31	,,	,,	7
,, 22	60	36	9 0	10 30	5 25	3 0	40	4 3	40	,,	,,	7
,, 24	—	—	—	—	—	—	—	—	—	—	—	—
,, 25	55	43	6 0	7 15	12 55	3 30	55	4 2	55	,,	,,	7

THE HURD COAL-CUTTING MACHINE.

No. of Times that Cutters were changed.	Fused.	At the Surface. Volts.	Amperes.	Steam-pressure per square inch.	Remarks.
			From	Pounds	
3	3	380	— —	80	Bar was fast for 1½ hours; numerous pieces of face, etc., were picked off, so as to allow sleeve to work.
3	?	400	— —	80	Advised cutting ½ inch off the blade of the cleaner-bar. Many little hindrances.
1	?	400	40 to 50	80	A portion of the face had become round, and machine finished holing in order that it might be removed.
3	?	400	40 ,, 50	80	Machine up to hand-holed coal, and must stand until loaded out. Telephone wrong, waited 20 minutes for current.
—	—	—	—	—	No face ready for machine.
2	3	400	40 ,, 50	80	Waited 1½ hours for electric current. Crooked face affected the cutting. A rail was broken. The cleaner-bar was not so efficient as at first.
2	—	410	10 ,, 60	80	Altered cleaner-bar as at first. Waited for 2½ hours, while some coal was got off. End of district.
					Easter holidays.
—	—	—	—	—	It took 8½ hours to turn the machine in a favourable place.
3	3	400	50 ,, 60	80	Commenced cutting with 4½ feet bar. Commenced cutting to the dip, and cutters stood badly.
3	?	400	50 ,, 60	80	Changed cutter-bars at 10 p.m. Machine still running sluggish with 4 feet cutting-bar.
1		400	50 ,, 60	80	Turned machine at a bend in the face, so as to take off a extra web. Cutting to the rise.
3	2	400	50 ,, 60	80	A rail broke under the machine, and caused delay of 1 hour. Had some coals to get off. Cutting to the rise.
1	—	400	50 ,, 60	80	Waited 1½ hours for current. Finished up into top-end of No. 5 stall.
—	—	410	60 ,, 60	80	Deputy turned machine, and commenced to cut. Cutting to the dip.
2	?	410	40 ,, 50	80	Machine off the road. Cut up into bats and coal. Deputy in charge. Cutting to the dip.
1	?	400	50 ,, 60	80	Telephone not properly switched to Ld. Delayed 1½ hours, the machine being off the road. Cutting to the dip.
3	4	410	50 ,, 60	80	Waiting of current for 45 minutes. Machine sluggish. Cutting to the dip.
3	2	410	50 ,, 60	80	Attended to commutator for 40 minutes. Machine sluggish. Cutting to the dip.
3	?	410	50 ,, 60	80	Some floor was dinted before the road was laid. Cutting to the dip.
3	?	410	50 ,, 60	80	Current became weaker as the bottom-end of the district was reached. Cutting to the dip.
1	?	405	50 ,, 60	80	Finished into end of No. 8 stall. Decided to cease cutting to the dip.
—	?	400	50 ,, 60	80	A fall of roof hindered the turning of the machine. Commenced to cut to the rise.
2	?	440	50 ,, 60	80	Raised voltage at the surface. Rimed holes out of new bar for cutters. Cutting to the rise.
2	?	440	50 ,, 60	80	Machine doing better at the higher voltage. One man more employed with machine.
2	?	450	50 ,, 60	80	Cable was fused near the machine. Decided to lay road during day-time for machine.
4	?	440	50 ,, 60	80	Machine off the road. Cable fused. An extra roadlayer was employed. Finished at the top-end of the district.
—		—	—		Flitted the machine from No. 5 to No. 8 stall, along gateroads and engine-plane. It was loaded upon a low trolley, and taken to bottom-end of district.
2	?	450	40 ,, 50	80	Had difficulty at bottom-end, owing to floor not being taken up.
4	?	450	40 ,, 50	80	Machine worked well.
3	?	450	40 ,, 50	80	Machine worked well, and men laid 3½ pairs of rails.
2	?	460	40 ,, 50	80	Had some coals to get off.
—	—	460	40 ,, 40	72	Flitted machine, and commenced to cut.
3	2	460	40 ,, 50	80	Cutting-bar entered too deep, and wore cutters by the tilting of the machine.
4	—	460	40 ,, 50	80	Workmen laid 23 yards of road.
4	—	460	40 ,, 50	80	Machine worked well. Finished into end of No. 5 stall.
—	—	460	40 ,, 50	80	Flitted machine from No. 5 to No. 8 stall. It was loaded upon a bogey, and put into end ready for starting.
3	4	470	50 ,, 60	80	Put on 4½ feet cutting-bar. Machine went sluggish. Took off cleaner-bar, and machine doubled its speed.
4	12	460	50 ,, 60	80	Took blade off cleaner-bar. Machine went better, but left in the dirt.
—	—	—	—		Only 17 yards ready, owin to short time.
3	?	460	50 ,, 60	80	Machine going better, but using cutting-bar without blade.

TABLE II.—DETAILS OF THE WORKING OF

1903.	Length of Face ready for the Machine.	Length of Rails laid for the Machine.	Machinemen went down at	Machine commenced Cutting at	Machine finished Cutting at	Actual Time that the Machine was Cutting.	Distance cut.	Average Depth of the Undercut.	Distance Cut in the Floor.	Distance Cut in the Bats.	Distance Cut in the Coal.	Men Employed at the Machine.
	Yards.	Yards.	P.M.	H. M.	H. M.	H. M.	Yards.	Ft. In.	Yards.	Yards.	Yards.	
May 26	41	35	9 0	10 15	3 0	3 10	38	4 2	—	—	—	7
,, 27	—	—	—	—	—	—	—	—	—	—	—	—
,, 28	64	23	9 0	10 0	5 15	4 0	60	3 10	—	—	—	8
,, 29	60	50	9 0	10 25	5 10	3 55	60	3 11	—	—	—	8
June 3	48	48	9 0	10 40	3 15	2 55	48	3 11	—	—	—	8
,, 4	—	—	—	—	—	—	—	—	—	—	—	—
,, 5	68	50	9 0	11 15	7 10	3 24	50	3 11	—	—	—	8
,, 8	78	55	9 0	10 10	4 30	2 45	57	3 10	—	—	—	8
,, 9	63	50	9 0	10 50	5 40	3 10	51	3 11	—	—	—	8
,, 10	72	48	9 0	9 25	10 35	0 45	10	3 10	—	—	—	8
,, 11	98	55	9 0	12 0	5 25	3 5	50	3 10	None.	50	—	8
,, 12	120	50	6 0	7 0	6 25	3 25	77	3 10	77	None.		8
,, 14	46	46	12 0	1 10	6 5	2 25	33	3 10	33	,,	—	6
,, 15	36	12	9 0	9 55	11 10	0 50	12	3 10	12	,,	None.	8
,, 16	46	36	9 0	2 10	5 15	1 10	20	3 9	20	,,	,,	8
,, 17	130	50	9 0	10 20	5 10	2 40	58	3 9	58	,,	,,	8
,, 18	97	50	9 0	10 25	5 10	3 15	55	3 9	55	,,	,,	8
,, 19	82	42	9 0	10 20	4 0	2 20	42	3 9	42	,,	,,	8
,, 21	50	25	9 0	4 20	5 40	1 20	21	3 10	21	,,	,,	7
,, 22	62	55	9 0	10 5	5 20	3 20	63	3 10	63	,,	,,	8
,, 23	70	50	9 0	10 20	4 50	2 25	43	3 9	43	,,	,,	8
,, 24	47	47	9 0	9 55	5 20	2 40	46	3 9	46	,,	,,	8
,, 25	70	15	9 0	4 45	5 20	0 35	9	3 10	9	,,	,,	7
,, 26	120	50	6 0	8 25	6 10	4 45	83	3 9	83	,,	,,	8
,, 29	88	50	9 0	7 30	2 20	2 10	39	3 9	39	,,	,,	8
,, 30	49	49	9 0	10 35	3 35	2 30	49	3 9	49	,,	,,	8

results, and the quicker will its work be found a success, or a failure. Careless road-laying, for a machine, will quickly make a straight face crooked; therefore, having made the face straight for the machine, the rails should be laid at a given distance from the holing-dirt, and not from the coal-face, which may overhang here and there, and no variation should be allowed. The distance enforced by the writer is 18 inches for a 4 feet bar, and 20 inches for a 4½ feet bar; 20 inches is undoubtedly the best, as, at that distance, the sleeve into which the bar fits will not rub against the holing-dirt, causing unnecessary friction; but with 18 inches, a 4 feet bar seldom cuts up to 4 feet, and with 20 inches, a 4½ feet bar will cut about 4 feet 2 inches on an average.

THE HURD COAL-CUTTING MACHINE.—*Continued.*

No. of Times that Cutters were changed.	At the Surface. Fuses.	Volts.	Amperes.	Steam-pressure per square inch.	Remarks.
			From	Pounds	
2	?	460	50 to 60	80	Had some road laid, and got the machine back along the gate-road of No. 5 stall.
—	—	—	—	—	Machine was run on the road of 22 inches gauge from No. 5 to No. 8 stall, and was left ready for cutting.
3	?	450	60 to 60	80	The 4 feet cutting-bar was put on, and the cleaner-bar as at first. Machine went well.
2	3	450	40 ,, 50	80	Machine cut upward into coal. One set of cutters cut a length of 45 yards. Machine went well.
					Whitsuntide holidays.
2	1	450	— 50	80	Machine cut into end of No. 5 stall. Machine was run back into gate-end ready for flitting.
—	—	—	—	—	Machine was taken from No. 5 to No. 8 stall, on road of 22 inches gauge. Machine twice off the rails, due to the new wheels coming off.
4	2	455	— 50	80	Parallel cutter-bar put on at end of shift, but the end-cutters were too long.
3	None.	450	— 35	80	Machine cut upward into coal, and stood 1½ hours while coal was being loaded out.
3	,,	450	— 40	80	The previous cut was badly done, and affected this cut very much.
None.	—	420	— 40	50	Finished into end, and ran machine round to end of No. 8 stall.
3	—	420	— 40	50	Machine cut in bats all night. Coal fell off at several points.
7	—	450	— 45	80	Three changes, due to short-end of cutters coming out. Machine went badly.
2	—	410	— 45	50	Machine not going well, due to end-cutters being badly arranged.
None.	—	440	— 50	70	Finished cutting into end, and ran machine back to gate-lip of No. 8 stall.
1	—	450	— 50	80	Machine got into bottom-end of No. 8 stall. Found an ironstone-ball, 18 inches in diameter, and had to cut up, over and down.
3	1	450	— 45	80	Overhanging coals caused two stands. Machine going well.
3	3	450	— 50	80	Put on parallel cleaner-bar, it caused too much dirt to be brought out.
4	4	450	— 50	80	Cut into end, and commenced to run round machine.
1	None.	450	— 50	80	Finished flitting, and commenced to cut.
3	3	450	— 45	80	Machine going well. No difficulties.
3	3	450	— 45	80	Bad roof throughout shift. Machine off the road, as a sprag slipped out.
5	12	450	— 50	80	Cut into end of district. Machine run to plate.
None.	None.	450	— 50	80	Machine run round, and commenced to cut.
4	1	450	— 50	80	Machine going well.
5	1	450	— 50	80	End-cutters caused numerous stands, and had to stop for want of end-cutters.
4	None.	450	— 45	80	End of district.

Cleaning out Dirt.—The hand-holer gets down his dirt, casts it either into the pack-walls or into the goaf; and in working a machine, all the cost of preparing the coal ready for loading must be placed to the debit of the coal-cutting machine. The trailer-bar travelling behind the cutter-bar can be made to do much or little in bringing out the holing-dirt, according to the angle at which it is set to the cutter-bar; but it is not wise to make it bring out too much dirt, because this will be at the expense of the cutting-speed of the machine. There is, however, an efficient medium, and that is to arrange so that it brings out to the sleeve about one-third of the dirt made, the remainder being removed by the man or men employed for the purpose.

Probably, with two-thirds of the dirt to scrape out and shovel into the waste, about 30 or 35 yards, 4 feet under will be enough for one man in his shift. It is of the greatest importance that this work should be well done, and the dirt properly removed from the extremity of the cut, otherwise the coal sits upon the dirt; and then it becomes difficult, if not impossible, to get it down for the loaders, and it renders the work of loading more difficult. The removal of this dirt should be effected before the men who work the machine leave the district, otherwise the gradual weighting of the cut-coal makes it difficult to remove it; and so firm does it become that the writer has had to introduce a special pick to loosen it, before it can be scraped and shovelled out. This neglectful system adds considerably to the cost of coal-cutting by machinery.

Holing or Heads for the Machine.—The bar-machine, like the disc-machine, requires commencing and finishing places preparing for it, at each end of the face upon which it works. Where it begins, hand-holing, 6 feet in length and of a depth equal to the length of the bar used must be made, and where it finishes, a length of about 12 feet of the same depth. The extra length at the finishing-end is due to the cutter-bar being at one end of the machine, and also to the extra distance rendered necessary by the haulage-prop. This work is costly in hard holing, but it must be made for every web cut, or heads must be driven in advance of the same width. The bar-machine is supposed to cut itself into a solid face, but the wear and strain in hard holing are such as to prevent it from being recommended or adopted. There is a tendency for the ends of the face to get behind, and they must be very carefully watched.

Machine-cut Coal.—Much has been said about the advantages of machine-cut coal, compared with coal won by hand-holing, and in some seams there is an increase of large coal, but this does not apply to every seam. The saving is greatest where, in hand-holing, it is necessary to slot the face of the coal in order for the holer to do his work (Fig. 4, Plate IX.); but, again, this saving is partly counteracted by the small-coal made in breaking machine-cut coal ready for filling into trams; and this is due to the short distance that the front of the web falls before it touches the floor (Fig. 5, Plate IX.). There is no room,

over the top of the fallen web, for the loader to use his pick or nuper, and he must break the coals at the end of the web. If the face is worked end-on, as most tender coals are, the loader cannot avoid making more slack than he would with hand-holed coal.

Having had to slot the Tupton coal-seam, a small increase is experienced in the percentage of large coal, but there is quite as much slack. The writer works one coal-seam, 3 feet thick, where no slotting is done, and the depth of the holing is frequently 6 feet, but there is 12 to 15 inches of easy holing dirt. If a machine were sent to cut in this seam, it would be set to work near the bottom of the coal; therefore, in this seam a lower percentage of large coal would be produced, and a higher percentage of slack. This fact is merely mentioned as a proof that all seams, if worked by a machine, would not yield more large coal and less slack. Nevertheless, the writer believes that it would pay to work this seam by machine, as it has a good roof, a soft floor, and is worked at a high-charter price; and a length of 100 yards, cut to a depth of 4 feet, might reasonably be expected from a coal-cutting machine in a 9 hours shift.

Weighting of Coal-face.—Where hand-holing is employed, the weight comes over the face very irregularly, making it necessary to hole to a good depth, in order to get the coal without resorting to explosives. This is due to the work of hand-holing being slow, and often intermittent, from the commencement to the finish, and the comparatively short distance done in each working-place per shift. But, with machine-cut coal, the whole depth is cut at one-and-the-same time, and the distance per shift in any one working-place is greatly exceeded; therefore the weighting of the coal is more uniform and continuous, and in most cases, the coal could be got as soon as the cleaning-out of the dirt is finished. The writer has been agreeably surprised to find that a web, holed 4 feet deep by a machine, comes down quite as easily as a web 5 feet to 5½ feet deep holed by hand; and, generally speaking, the breaking-off of the coal from the solid is much straighter and more uniform.

Reports.—At the commencement of coal-cutting by machines, the writer had reports specially arranged for the coal-cutting

district. These are filled in and signed by the deputies, and sent to the office at the close of each shift, and countersigned by the under-manager (Appendices A, B and C). These reports shew the conditions of working in the district during each shift, and bring to the notice of the under-manager any circumstance, however trivial, that would affect the successful working of the machine. In order that a machine may have a fair trial, the underground officials must see the necessity of replacing hand-holing, and if they have much difficulty in getting men to work, they will welcome anything that will remove the difficulty. The under-manager should have full control (in the absence of, and subject to the consent of, the manager) of the machine, directing when it shall cut; and if matters are so arranged, he becomes so anxious to succeed, that all his arrangements for each shift's work are conducive to safety, as well as to financial success, if possible. No other arrangement would be satisfactory.

In order to give the machine a fair trial, one of the most experienced deputies was sent with it for 6 weeks, in addition to the full staff of men for running the machine. He was, then, replaced by a less experienced deputy, who remains only for a portion of his shift (about half), and when everyone becomes accustomed to his work, he will be withdrawn and replaced by the regular night-shift deputy.

Conclusion.—In concluding these notes on the Hurd coal-cutting machine, it is only fair to explain why the distance cut at the extreme bottom-end of the district during the cutting of the first three webs was smaller than it is now. The machine is designed for 350 volts, and the dynamo for 400 volts; the drop of pressure is about 100 volts; and consequently the machine was working under its proper voltage. The dynamo was then run at 450 volts, an unwise arrangement; but circumstances demanded it, and previous experience had proved that the dynamo was quite equal to it. The running of the machine improved at once, and it has done its work efficiently with the 4 feet bar, when cutting to the rise.

APPENDIX A.—ENGINEER'S REPORT.

May 7th, 1903.

Time.	Steam-pressure. Pounds per Sq. Inch.	Volts.	Ampères.	Remarks.
p.m.				
6·0	...	...	...	Machine standing.
7·0	...	..	...	Do.
8·0	82	450	50	
9·0	82	445	50 to 60	
10·55	82	450	50	
11·35	82	455	40 to 50	
12·0	..	...	...	Snap-time.
a.m.				
1·20	80	435	60	
2·15	88	460	50 to 60	
3·0	...	...	...	
4·0	.	...	...	
5·0	82	445	50 to 60	
6·0	..	...	...	Finished.

T. GOSLING.

APPENDIX B.—DAY-SHIFT DEPUTY'S REPORT IN COAL-CUTTING DISTRICT.

Tupton Seam, May 7th, 1903.

What stalls have been turning to-day? *Nos. 7 and 8, and No. 8 cross-gateway.*
How many loaders have been at work? ... *2 in each place or 6 in all.*
How many trams have been loaded? *No. 7 gateway, 46; No. 8 cross-gateway, 37; No. 8 gateway, 23; a total of 106 trams.*
Have the loaders had plenty of trams? ... ... *Yes.*
Where shall loaders work to-night? ... ... *None required.*
How many yards of face were ready for the machine at 4 p.m.? ... *73.*

J. STANLEY, T.W.

APPENDIX C. NIGHT-SHIFT DEPUTY'S COAL-CUTTING REPORT.

Tupton Seam, May 7th, 1903.

	Hrs. Mins.
Machine commenced cutting at	*8 0 p.m.*
Machine finished cutting at	*5 30 a.m.*
Time cutting	*9 40*
Position of machine at 6 p.m.	*Between Nos. 6 and 7 gateways.*
Position of machine at 5·30 a.m.	*Below No. 5 gateway.*
Number of yards cut	*50.*
Has the machine cut in the floor all night?	*Yes.*
	Ft. Ins.
Greatest depth of undercut	*4 0*
Least depth of undercut	*3 8*
Average depth of undercut	*3 10*
Have there been any avoidable stands?	*None.*
Explain them.	

The machine has been going fairly well during the night.

How much face is ready for machine for next shift? *About 40 yards from the machine to the top-end.*
How many stalls have been turned this shift? ... ... *None.*
How many loaders have been at work? ... .. *None.*
How many trams have been loaded? ... ... *None.*
What stalls want loaders for day-shift? ... ... *Nos. 6 and 7.*
What special attention is required, and where, for forwarding machine to-night? ... ... *Road to be laid ready.*
Could you suggest anything which would assist either the machine or the getting ready for the machine? ... ... *No.*
The cable has been fused next to the machine.

G. CUTT., T.W.

Mr. AUSTIN KIRKUP (Lambton Collieries) wrote that he had had no actual experience in working bar-machines, but he was interested to note that good results had been obtained by the use of the parallel cutter-bar: more yardage being cut, and less power being used. He (Mr. Kirkup) thought that there were certain conditions under which the parallel bar would give some trouble. If the coal-face be given to weighting very quickly after being cut, as he had often found in seams in the county of Durham, he thought that the parallel bar would sometimes be very difficult to remove from under the cut, when it was necessary to change it. Mr Walker said nothing about difficulties in this connexion, and it would be interesting to know if he had experienced them. He asked whether Mr. Walker had experienced any difficulty in putting a bar, charged with new cutters into a cut, after having taken out the old cutters. The old cutters being worn and blunt, the cut would be appreciably less in height and would not accommodate a bar fitted with new cutters; and he (Mr. Kirkup) thought that under such conditions, the parallel bar would be likely to cause trouble. He observed what Mr. Walker had stated in regard to the charging of the bar with cutters: the time taken being one hour, and sometimes more. He thought that this was a very long time, and certainly it did not compare favourably with the time taken to fix the cutters and cutter-boxes upon a disc-machine: an operation usually completed in from 10 to 15 minutes. If the coal-cutter be working in hard material, necessitating frequent changing of the cutter-bits, it will be recognized that a considerable proportion of the workmen's time will be occupied in changing the cutters. He

To illustrate Mr. W. Walker's Paper on "Electric Coal-cutting."

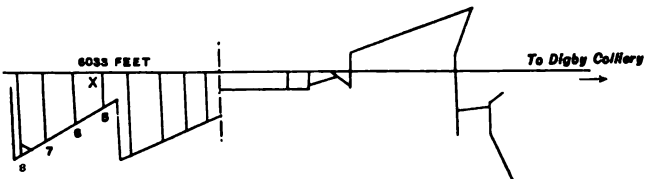


FIG. 2.—SKETCH-PLAN OF WORKINGS IN TUPTON COAL-SEAM.

Scale, 880 Feet to 1 Inch.

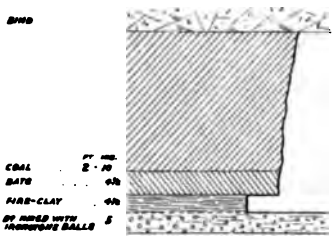
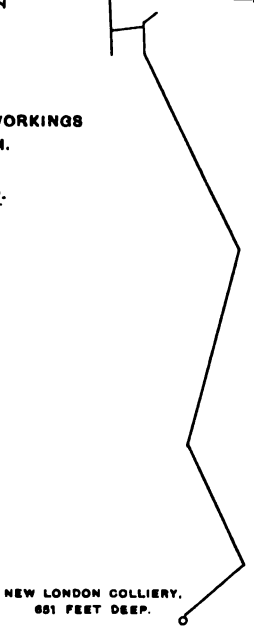
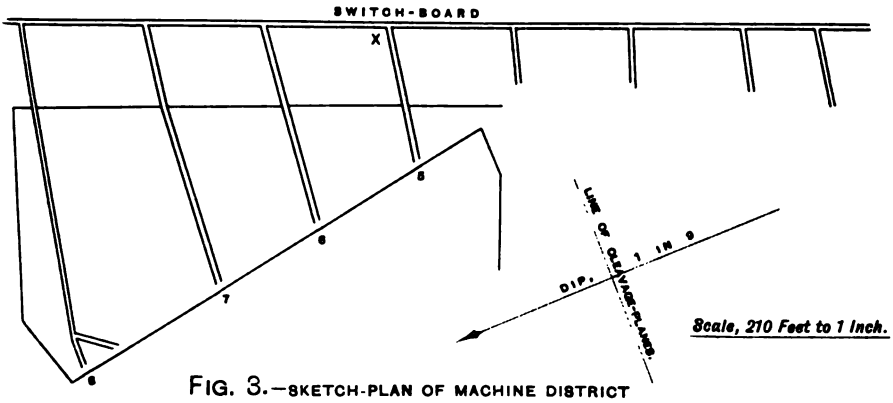


FIG. 1.

Scale, 4 Feet to 1 Inch.





Scale, 210 Feet to 1 Inch.

FIG. 3.—SKETCH-PLAN OF MACHINE DISTRICT IN TUPTON COAL-SEAM.

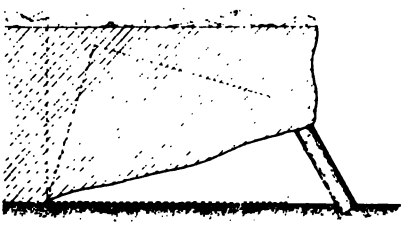


FIG. 4.—COAL DROPPED, AFTER HAND-HOLING, IS SHOWN BY DOTTED LINES.

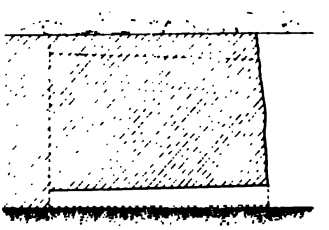


FIG. 5.—COAL DROPPED, AFTER MACHINE HOLING, IS SHEWN BY DOTTED LINES.

Scale, 4 Feet to 1 Inch.

And^w Reid & Comp^y L^td Newcastle on Tyne

thought that it would be desirable, if engineers; who are using bar-machines, could devise arrangements whereby the cutters could be changed in a shorter time.

Mr. H. F. Bulman (Burnopfield) wrote that the disc- and the bar-machines first tried in the Deep Hard coal-seam failed to give satisfaction, owing to the presence in the fire-clay-holing of ironstone-balls, 1 inch to 3 inches in diameter, lying more or less in pockets. An endless-chain machine might have given better results: a chain, travelling at the rate of 200 feet per minute or more, had a powerful tearing-action, and these machines sometimes pulled out large lumps of material.

Why so many more men than usual were employed with the machines (six or seven men) was not apparent, as the roof was good, and the average distance cut was only about 20 yards a shift: this high cost of labour would tell against the machine.

The height of the seam, $2\frac{3}{4}$ feet, would not preclude a machine cutting in the coal, but, presumably, the quality of the coal is too good to admit of 4 to 5 inches of it being sacrificed to the cut. Otherwise, if it "could easily have cut a distance of 100 yards in 9 hours" "in coal," and if this distance (or something like it) could have been accomplished daily, there could be little doubt as to the advantages in increased production per man and reduced cost per ton that might be secured, in comparison with hand-holing.

With regard to the length of the bar in the Hurd machine, cutting in the Tupton Low Main seam, at a gradient of 1 in 9, one would like to know why 4 feet was the correct length of "the correctly threaded bar to use when cutting to the rise," whereas in cutting to the dip a longer bar was used. Possibly, this greater length of bar might have something to do with the increased difficulty experienced in cutting down the slope. The opinion that a 4 feet bar is the longest that can be used successfully is hardly corroborated by general experience, as there are several instances of these machines giving satisfactory results with a deeper cut than this. It can hardly be accepted as an axiom that on such gradients as this (1 in 9) a machine will always cut better to the rise than to the dip.

The turning of the machines at the ends of the face in order to cut both ways is certainly a drawback to a bar- or chain-

machine, in comparison with a disc-machine which does not need to be turned, but he (Mr. Bulman) understood that the Hurd machine had been adapted to cutting both ways without turning, by substituting another bar, with the worm turned in the opposite direction.

As to the laying of a third rail for flitting, is this preferred to attaching fresh sets of wheels of the required gauge, when the machine has reached the end of the face? This is the method adopted at many collieries, and it seems to be simpler than laying a third rail all along the back roads.

The excessive heating of the thin end of the cutting-bar seems to have been due entirely to its contact with the ironstone-balls, owing to the machine being tilted: but it is not clear why the machine was tilted. In the Hurd machine, the gear-box, in which the outer end of the bar is centred, can be tilted apart from the rest of the machine, and thus the bar can be set at any desired slope, either upward or downward, without tilting the machine.

With regard to the better results obtained with a parallel cutting-bar, may not this have been due partly at least to its having been kept at the right level, avoiding the ironstone-nodules below and the hard bats above? It would be useful to know how long the trials lasted, during which the power consumed was tested. It is not easy to understand why a heavier bar cutting in the same material should require less power, owing to its being made parallel instead of a tapered form. Possibly the strains on it may be more uniform.

The exceptional hardness of the holing suggests that more time would be available for road-laying rather than less, as the advance of the machine would be slower than in a softer holing. The angle at which the bar is set with the machine has some effect on the outward thrust. Was it an acute or an obtuse angle in this case? It had been found in some instances that when set at a slightly acute angle, the tendency was to keep the machine up to the face and to lessen the outward thrust. Where the same rails can be used for running the machine and for loading out the coals, the laying of the way for the entire length of the working-face, previously to the machine-shift, must certainly reduce the labour required. But some further explanation is desirable as to "the extra tilt [height?]

that must invariably be given to the goaf-side rail, and the extra packing of this rail." In the ordinary Hurd machine, the bar can be tilted vertically without tilting the machine. If it be desired to tilt the machine, though one does not see the necessity, that may be done without raising the goaf-side rail, by using wheels on that rail of a larger diameter than on the inner rail. This avoids the extra labour of chocking-up the outer rail.

To prevent delay in changing cutters, and to ensure their being properly fixed, it is sometimes a good plan to keep at hand a spare cutting-bar with the cutters already fixed.

The trouble in clearing out the cuttings is a draw-back to the bar-machine, in comparison with disc- or endless-chain machines, although the bar has compensating advantages. A colliery-manager, who has had much experience with a variety of machines, told the writer not long ago that he intended having a bar-machine constructed with a separate worm-conveyor and shield behind the bar for the purpose of clearing out the cuttings.

One of the compensating advantages of the cutting-bar, in its ordinary tapered form, is in the falling of the coal. The extra height of the holing in front gives more room for the coal to fall before touching the floor, and the freer break of the coal assists the getting of it. Mr. Walker referred to the difficulty of getting the fallen coal from the front, owing to the want of room (over the top of it) for the loader to use his pick. It is more usual for the loader to get the coal from the loose-end or side.

In one instance, where a 3 feet seam is under-cut to a depth of 4 feet by a disc-machine, a vertical cut (nicking), 3 inches wide by 5 feet deep, is made the full height of the seam at intervals of 11 yards by an Ingersoll percussive machine. This is found to be necessary for the getting of the seam, which contains a hard stone-band about 2 inches thick in the centre.

If the coal is so soft and full of backs that it cannot be got in good-sized pieces, when approached from a loose-end, it is hardly suitable for machine-cutting, because, probably, the coal will fall on the machine while it is cutting. A reduction in the percentage of large coal with machine-cutting is quite exceptional, and certainly in the great majority of cases more large coal is secured.

Few mining engineers will differ from Mr. Walker's opinion

that, owing to the modern tendencies of workmen, "coal-holing machines are thus becoming a necessity in thin seams, with hard or moderately hard holing," but some of his other statements as to the applicability of these machines are open to dispute. They are at work with undoubted success in seams up to 6 feet in thickness, and there appears to be no reason to fix this height as the limit. Bad roofs are not an insuperable obstacle. On the contrary, owing to the more rapid advance of the face, which may be attained by the use of machines, to the straightness of the face, and to the systematic timbering and support of the roof, which they require, a bad roof may be an additional reason for adopting machine-cutting.

Longwall machines are not, of course, adapted to bord-and-pillar workings, but the great advantages that may often be derived from the use of percussive machines (the Ingersoll and the Champion), or of chain-headers (the Jeffrey), or of rotary headers (the Stanley), in narrow places, are now well proved, not only in the United States and in British colonies (Canada and New Zealand) but also in Great Britain. The reason why some of the percussive machines have sometimes failed to give satisfaction, is that the air-pressure has not been sufficient for hard coal.

In his (Mr. Bulman's) opinion, the limiting factor to the applicability of coal-cutting machines lies chiefly in the human element. Their successful adoption, under most conditions and for the most part, depends on the men employed with them, including the officials.

Mr. Arnold Lupton (Leeds) wrote that Mr. Walker's is an interesting paper, showing some of the difficulties that have to be encountered in introducing coal-cutting machinery, and also showing how they may be overcome by a little patient consideration and invention. Mr. Walker's invention of the parallel bar seems to be very clever and sound. It appears that Mr. Walker had to run his dynamo up to 450 volts in order to obtain a voltage of 350 at the coal-cutter, thus showing a loss of power of 22 per cent. in transmission. It would be interesting to know whether there were any other demands upon the dynamo besides that of the coal-cutter. In *Electricity as applied to Mining* published this year, in the compilation of which he took some part, there

is given a table from which to calculate the size of cable required for any given drop in voltage for any given length. According to that, if the number of ampères transmitted was only 50, and the cable consisted of 19 wires of No. 14 wire-gauge, the loss in transmission should have been about 1·3 volts per 100 yards; and since the distance each way is about 2,000 yards, the loss in voltage would be (40 by 1·3, or), say, 52 volts, and, according to the same table, the rise in temperature in the cable would be much under 10° Fahr.

Mr. A. H. Stokes (H.M. Inspector of Mines) said that he did not agree with the remark that "the young colliers of to-day are not trained to hard work." No doubt their fathers got coal by the dogged application of animal force, whereas the young collier of to-day exercises skill, and with less manual force obtains better results; and, probably, as our miners become better educated, they will still further improve their knowledge of the laws of conservation of energy. Mr. Walker gives some rather curious results with respect to the tapered and the parallel bar, showing that the parallel, or larger cut, took less power than the tapered or smaller cut. This appears to be a result that might be made the subject of further enquiry or experiment. In the form of report (Appendix C.), there is one very attractive remark, namely:—"Cable has been fuzed next the machine": one would like to know how often this occurs, and what is the cause.

Mr. G. Hooghwinkel (London), referring to Mr. Walker's experience at the New London colliery with the Scott-and-Mountain diamond coal-cutter in the Deep Hard coal, when this type of machine failed, wrote that he would like to relate his experience with the Garforth diamond disc-cutter of a similar construction, at the Dorstfeld mine in the Ruhr coal-field. The seam was not very different from that at New London colliery, 2 feet 6 inches thick, with a bad roof and a good floor, and very hard holing, which was deemed to be unworkable by hand-labour. The face also rose at an angle of 1 in 9, but this was reduced to 1 in 12 for the seam. Of course, only the longwall system was tried, as generally disc-machines take too much room for the stoop-and-pillar system. The distance cut per shift varied, but was about 70 yards on an

average and 120 yards as a maximum. The machine was guaranteed to cut 60 yards, 6 feet under, in 9 hours. The output, per day of two 8 hours shifts, was about 130 square yards, and 70 per cent. was large coal. The holing in this seam was very hard, and the working was considered impossible by hand-labour. The roof was timbered on the ordinary crossbar-and-prop system, the crossbars (every yard) being supported by the coal-face on one side. After the machine had passed a bar, the end in the coal-face was supported at once by a prop. This forced the men to follow closely with the timbering. Only three men were required instead of six or seven: one laid the rails, and packed them rigidly against the working-face and the props, in order to prevent the machine from pressing the rails from the face; the second cleaned out the holing-dirt at the wheel; and the third acted as a driver, placed the second prop, and also attended to the spragging. This type of cutter has now been at work in the above mine for about four years, and their output has improved every year. They are made to cut to the rise and in the same direction, by running them back to the gate-end.

Mr. R. Hood Haggie (Derby) wrote that it is always interesting to hear what other people are doing, although it does not always follow, even if it be a success in their experience, that it must therefore be the best way to do similar work at other places, or that it might not be still more successful if they employed another type of machine. For longwall work, the disc-machine is undoubtedly the stronger in the part that holds the tool, and in a hard holing it is very necessary to have everything about the machine of the strongest. Mr. Walker states that both a disc- and a bar-machine were failures in the Deep Hard coal-seam with ironstone-balls; but he evidently only tried one type of machine in the Tupton Main seam, and as the bar-machine did so well, it is more than likely that a disc-machine would do even better. The only advantage is that, with a bar-machine, it is possible to sprag every few inches, a necessity where the coal settles too quickly to allow the disc to get from under it, and in such a case, the bar must be used. Where, however, the coal is strong enough, the disc-machine has superseded the bar-machine in several instances. The bar-machine, in various forms, has been in

the field considerably longer than the disc-machine and yet the latter already largely outnumbers the bar-machine. The number of men required seems extravagant, as with a disc-machine the driver has generally to lay the road himself, and his mate clears the cut as well as shovels out at the back of the disc, and often if the road be good he has to timber as well; but generally there are four men, the driver, his mate, a cleaner-and-spragger, and a man for timbering.

Mr. Walker's idea that seams worked on the bord-and-pillar system could not have coal-cutting machinery profitably applied to them is a mistaken one, as the chain breast-machine is perfectly satisfactory for this system, and many mining-engineers contend that it is the only system by which to work certain coal-fields. With these machines, a place, 45 feet wide, can be undercut to a depth of 6 feet in about 2 hours, and, further, for opening out a coal-field where it is necessary to drive roads quickly they undoubtedly are eminently successful. The Digby Colliery Company have one of these machines at their Gedling colliery, and it is doing excellent work, although Mr. Walker does not seem to know of it. Where the holing is hard, this machine could also be economically and successfully used for cutting the stables for longwall coal-cutters, and so do away with the hewers in a coal-cutting face altogether.

Mr. J. Liddell (Wyken Colliery, Coventry) wrote that he had had three Hurd coal-cutting machines at work for the past three years. He had had, from time to time, these machines cutting on a rise of 1 in 9, and had frequently cut downhill. On cutting to the dip, the difficulty was got over by using a chain from behind the machine attached by about 1½ turns around a prop, thus giving a certain amount of tension behind the machine. Had the writer ever tried running the machine back on its own rails (when cutting was done) ready for recommencing on the next shift; and if so, how did the cost compare with flitting the machine around the gate-roads?

He differed from Mr. Walker with reference to the view that he took of the tapered cutting-bar. After three years' experience of this class of machine, he considered that one of the principal features of the tapered bar was that the deeper or thicker cut at the front of the holing and the smaller at the extreme

end, helped considerably to equalize the strain on both the bar and the machine, thus causing it very rarely to require the rails to be spragged. He was under the impression that on a former type of this machine a parallel bar was used, but not successfully: principally, on account of the bars breaking through being of equal size and strength throughout the length of the bar. In the tapered bar there was extra thickness of cutting at the front of the web of coal, and this allowed the coal to fall well over, which greatly facilitated the breaking up and loading out of the coal. He (Mr. Liddell) asked whether in either of the tests was any other power taken from the same generator at the same time, and was the power registered at the machine or at the surface? He also asked whether a shunt-wound motor was used on the machine; and, if so, the speed of the bar could not exceed the speed arranged for the tapered bar. Also whether Mr. Walker had yet tried the teeth of the cutter-bar on the thread; and, if so, how was the dirt worked out, as the thread was originally adopted on the bar to make it clear itself?

Mr. J. T. Todd (Blackwell Collieries) said that mechanical coal-getting was becoming of such vital and national importance, that any contribution to the already published experience was sure to receive appreciation. Mr. Walker was undoubtedly right in assuming that all seams were not suitable for mechanical coal-getting, and all machines were not suitable to every case. He would also suggest that Mr. Walker should add to the exceptions set out at the beginning of his paper "seams at a heavy gradient;" and that a mine intersected by numerous faults, if they were not too large or too close together, might be workable by coal-cutters. The development of coal-cutting by machinery had been slow, but this was probably due largely to the labour-difficulty and to the fact that many seams had been got quite as economically by hand-holing; but as these seams were exhausted, and as the cost of working increased, more attention would undoubtedly be directed towards machine-getting. Another deterrent had been the large outlay necessary in the case of using compressed air, whilst electricity, until recently, had been in the experimental stage, and those who had pioneered this power had had to work their way very cautiously through many difficulties

in using electrical plant. The workmen required more careful training in using electrical than in the case of compressed-air plant, and this together with the reluctance to carry electric power into mines liable to give off gas, tended against the alteration of existing conditions. It would be interesting to know whether in the first machines used by Mr. Walker the various breakdowns were mechanical or electrical, and of what nature? In his (Mr. Todd's) opinion, sufficient attention had not yet been given to the traction of the machine. The traction-drum was, say (on a disc-machine), 12 inches long by 5 or 6 inches in diameter, and it was usual to run out the rope around a snatch-block about 100 feet in advance; if the speed of traction was not altered, the machine, when progressing, must have a greater strain thrown on it, because the coiling of the rope increased the diameter of the drum, and hence an undue speed would be incurred, and the machine must travel faster. This might mean an overload, resulting in an electrical breakdown. Further, in the case of the bar-machine, the number of men necessary for the work appeared excessive, practically both machines required the services of 6 or more men, and the cost per ton for labour alone would be very high. There was every probability that a disc-machine would have given as good results as the bar-machine. He might mention that some years ago he inserted a shaft-cable in wooden boxes, 3 inches square, filled solidly with pitch and no trouble of any sort had been found, though the shaft was a very wet one. Mr. Walker's experience that cutting to the dip required more power than cutting to the rise, coincided with his (Mr. Todd's) experience with a disc-machine. In the short face, quoted in the paper, he agreed that the laying of rails, on which the machine could be run back to its starting-point, was an advantage. He could appreciate Mr. Walker's opinion with regard to the use of the parallel bar, although he had had no practical experience with it. In cutting, it was essential that the cutting tool should, at the back or far end, just touch the coal, otherwise a wedge of dirt would be left; this would break down and clog the cutter; and he imagined that it would be difficult with a tapered bar to avoid this. Road-laying was another important item, and after some experience with disc-machines he had found that the best results were obtained by laying rails, weighing 30 pounds per yard, in

10 feet lengths; these, while being rigid, were sufficiently light to be easily handled, and carried the machine satisfactorily. There was a considerable increase by machine-holing in the output of round coal per acre. From his own experiments he was satisfied that machines saved from 5 to 10 per cent. as compared with hand-holing, but the necessary breaking up of the coal after being holed by the machine produced rather more slack than that caused by hand-holing; the increase of round coal, however, was about 7 or 8 per cent. in favour of machine-holing. It would be interesting to know something of the cost per ton of labour in cutting by the Hurd bar-machine, over an extended period, as compared with the disc-machine. At the present time, he was cutting, with disc-machines, about 750 or 800 tons per day. The holing was of a hard nature, but, on an average, each machine cut 14,000 tons last year, and often under difficulties such as those described by Mr. Walker. In no case, were more than 3 men engaged with one machine: this was an important item. He agreed with Mr. Walker that it was absolutely necessary to have detailed daily reports of the work of every machine, and he had found them most valuable.

In deciding on the question of the introduction of coal-cutting machines, he was of opinion that where coal could be got by hand for less than 2s. per ton, basis price, their use would not be economical in the present state of labour. He would be glad if the writer could give them some idea of the horsepower required to run the machines light, and also when under full work: and, further, whether any of the difficulties encountered in working the machines were electrical or mechanical.

Mr. J. C. Forrest (Hollybank Collieries) said that the Hurd bar-machine gave a 4 feet holing, and this was considered to be the most economical distance. In his own experience with machines during the past two or three years he had found that it was useless to hole to a less depth than 5½ feet, if machine-holing was to be made profitable, for it was the last 18 inches that told. By hand-holing, they could attain a depth of 3½ feet or 4 feet. In his case, 3 men followed each machine, and they had to stop frequently, not so much owing to danger from the roof, but because the coal kept rolling from the face. With machine-holing, the roof was safer, because they were compelled to carry

timber and to place it at stated intervals for their own protection. The most important consideration of this question was the commercial result. At a charter-price of 2s. 3d. per ton, unless there was a saving of 1s. per ton in a seam 5½ feet thick, the machine was not paying its way; with seams from 3½ feet to 4 feet thick, and a charter-price of 2s. 9d. per ton, a saving of 1s. 6d. per ton by machine-holing was necessary before their use was justified; and so on in proportion. He was now speaking of coal-cutters driven by compressed air, and admitted that machines driven by electricity might be slightly cheaper, but with probably more breakdowns. He had proved conclusively that if they did not get the value due to holing to a greater depth than hand-holing, they were giving away what belonged to the colliery-owner and to themselves as managers. He holed last year over 100,000 tons, and he did not think that he had gained 1d. from better coal; the only advantage being the less tonnage-price in the cost of holing.

Mr. W. B. M. Jackson (Clay Cross) said that it was interesting to know that Mr. Walker had made the bar-machine succeed where the disc-machine had failed. In the early days of coal-cutting, most mining engineers had to rely on the makers to tell them what power would be required, and he found it was often the case that a sufficiently powerful dynamo was not erected, or sufficient strength given to the holing machines. At his colliery, coal-cutting had been in vogue for many years, and a serious breakdown was now almost unknown. For many years, all their cutting was made to the rise (about 1 in 12), but for the past six months, they had been cutting to the dip, with a Clarke-and-Steavenson machine, and it took no more power to cut to the dip than to the rise, but the coal did not come down quite as well. The number of men employed at the machines by Mr. Walker was rather startling; in his own case they employed only 2 men as a rule, and an extra man was sent sometimes when the roof was bad. The whole of the cutting was done by contract, and the men were able to make extremely good wages. From careful experiments, there was only a saving of about 3 per cent. in slack coal.

Mr. Roslyn Holiday (Ackton Hall Colliery) said he was surprised that 4 feet was recommended as a limit, as he had been

using four bar-machines cutting to a depth of 5½ feet. The bars were tapered, and the nature of the seam varied considerably. They tried 4 feet bars at first, and found that they got a small quantity of coal. With 5½ feet bars, the coal broke down more freely. Mr. Walker did not recommend that the bar-machine should cut itself into the solid face, on account of the wear and strain, but he (Mr. Holiday) had a bar-machine, in which the bar started behind the machine parallel to the face. It worked its own way into the coal and gave no trouble. There were 3 men for each bar-machine, and the road was laid as the machine went along, some 150 to 180 feet in a shift of 8 hours. They had experienced many difficulties with disc-machines, due to the coal falling on the discs and stopping them. The shaking of the machine dropped the coal upon the disc and jammed it, or else the coal was broken into small. Eventually they abandoned the use of the disc-machine, and introduced the bar-machine, with which they were able to sprag the coal within 6 inches of the trailer-bar. He thought that they were about the first to try three-phase current for coal-cutting. They built the machines, they bought discs and motors (made in Switzerland), and cast-iron was not used in their construction. There was no sparking with three-phase machines, no important breakdowns, and the electrical part had given no trouble. The difficulties and breakdowns were due to the type of machine used, and if they paid the price asked by makers they would receive a machine which would do whatever work was required of it. In his case, the shaft-cables were carried from the surface clear to the bottom, and no trouble had been experienced with them. Mr. Walker stated that the cutters were arranged spirally on the bar, and later he referred to the cutters being placed in straight lines, stating that unless they were so placed they would not cut so well; this appeared to be a contradiction. Reference had also been made to the decreased percentage of small coal, but in his experience, the percentage of small had not diminished. They had a face of about 900 feet of coal, and were hand-holing in the same dip, and the conditions of the two faces were exactly alike, so far as one could tell.

Mr. William Hay (Shirebrook) asked what was the cost of the coal delivered into the cage, and whether the shape of the bar

was round or octagonal. He had had some experience of coal-cutting in a seam where they had many faults, and by the use of the Clarke-and-Steavenson machine had effected a saving of 1s. 2d. per ton. The machines were cutting in a seam of coal worked on the short stall-and-pillar system, the stalls being driven 120 feet wide and pillars were left 90 feet wide: this system was adopted owing to a seam overhead being heavily charged with water. The total cost of working that seam was 2s. 10d. per ton put into the cage, including 40 per cent. above basis-prices. He mentioned this case, to prove that coal-cutting machines could be usefully employed in short working-faces if well manipulated. In his case, they usually cut 120 feet and made a complete flit in 10 to 11 hours. The bord-and-pillar system of working was not extensively used in this county, but in heading by machinery a great amount of advantage could be obtained, by increasing the amount of large coal, and by decreasing the cost. After taking everything into account, he had affected a saving of £200 per annum by the use of a Jeffrey heading-machine in driving a heading, 9 feet wide, and there had not been more than 20 stoppages during the nine years that it had been in use.

Mr. R. J. Shaw (Ackton Hall Colliery) asked how the main cables were taken down the pit, how the coal was got away from the face after it had been cut, and the number of gateways at the face along which the permanent cable was taken, as this would affect the length of the face-cable, which suffered very heavily from wear-and-tear. He understood that the colliers used the machine-rails for the trams.

Mr. R. Laverick (Wollaton Collieries) said that, in limiting the length of the cutter-bar to 4 feet, Mr. Walker probably intended this to refer to his own particular seam. He understood from the section of the seam given in the paper that there was a hard floor, and it would not be prudent for the bar to go lower. Personally, he was using a 5½ feet bar, and had no difficulty with the cutting, because the dirt under the coal was uniform, and there was not a hard parting until they attained a depth of 2 feet. He had tried both tapered and parallel bars, within the last few months, and found that the parallel bar required exactly the same power as the tapered bar. He thought that the parallel

bar must necessarily take quite as much power, seeing that the cutting-surface was as great, if not greater. He thought that the question of the parallel bar was one of the most important and interesting points in Mr. Walker's paper. Personally, he had discontinued the use of the tapered bar, because he found when it was running from left to right, or in the same direction as the machine was running, that it had a tendency to climb into the coal. He ordered a parallel bar to run in the opposite direction, and instead of climbing and decreasing the height for the loaders, the tendency was to descend and make more height. Another disadvantage of the tapered bar was, when holing a thickness of about 12 inches of dirt from under the coal, the dirt between the top of the cutter-bar and the bottom of the seam was thickest at the back of the holing, owing to that end of the bar tapering in that direction, this prevented the dirt from falling, and it had to be forced down; whereas the parallel bar cut the dirt at one level for the whole depth of the holing, causing it to fall by gravity, and the cleaning out was done more expeditiously. They employed 4 men with each machine, and the rails were not laid along the whole length of the face. The question of traction had been mentioned; in the case of the disc-machine, as a rule, the traction was fixed, as there were a certain number of notches by which it was regulated; but in the bar-machine, the traction was regulated by the driver, and he thought that it was an advantageous arrangement.

Mr. Fred W. Hurd (Bothwell) said it probably happened that a cutting-machine was sent into some outlying district, where the conditions under which it was worked were not subject to much inspection; and perhaps wagons were not received in time to get the coal away, or other circumstances operated against the successful working, which were not taken into account in criticizing the machine. The number of holers required, the days worked, and the output, should all be taken into account in any comparison of its relative advantages with hand-labour. In most cases, the rate for holing was part and parcel of the total rate paid for getting and filling the coal. In the case of the first bar-machine at Digby colliery, the breakdowns were due solely to the fact that the motor driving the machine was series-wound and not shunt-wound. Electrically, the

machine gave no trouble whatever, but the holing was variable. The machine was sometimes cutting in material with ironstone-balls, and then would come into softer holing, and start away at excessive speed. On one occasion, when he was there, the motor was running at double its proper rate of speed; he called to the man to switch off the current, but he was too late, and a smash of the gearing occurred. The shunt-wound motor was now applied to the machine, and it was immaterial whether the cutting was hard or soft, or the machine was running light; there was no danger of the gearing being damaged through the machine being run at an excessive speed. He was very pleased to see that Mr. Walker emphasized the desirability of using the machine upon a straight working-face. He had been trying to instil this into all mining engineers with whom he had had to deal, and he was very pleased that its importance was beginning to be recognized. He agreed with Mr. Walker that the whole of the cost of cutting the coal—that is, leaving it exactly as the hand-holers would leave it—should be debited to the machine. As regarded the machine being worked with 3 and 4 men, he had worked it single-handed, and to work it with 2 men was common, but of course in such cases the dirt was not handled. At Digby colliery, there was about 18 inches of dirt to handle, and this necessitated the employment of 2 men entirely, and part of the time of a third. He thought that the true reason of less power being used by the parallel bar was to be found in connection with the reciprocating-gear attached to it.

Mr. J. A. Jeffrey (Columbus, Ohio, U.S.A.) wrote that Mr. Walker's paper referred almost wholly to the actual working of a longwall mining-machine of the cutter-bar type, using a special cutter-bar devised by the writer. The principal feature of this cutter-bar was that it was not tapered towards the inner end, but was made straight, so that the peripheral speed of the cutters was the same from one end of the bar to the other. Apparently the machine worked more successfully with this parallel bar than with the tapered bar.

Mr. Walker stated that "probably all mining-engineers would readily admit that coal-cutting machinery could not be profitably applied to all coal-seams at present being worked, for one or other of the following reasons," and the fourth

reason was "seams worked by the bord-and-pillar system."* In view of the success attending the operation of Jeffrey chain-breast mining-machines in room-and-pillar working, he certainly thought that Mr. Walker's statement was too broad. There were undoubtedly sometimes conditions which would render the employment of mining-machines unprofitable in the room-and-pillar system, and one of these conditions would be the use of ordinary longwall mining-machines. Mr. Walker further stated that the "longwall method of working . affords the best results from coal-cutting machinery," consequently, he (Mr. Jeffrey) felt that he must combine these two statements and take exception to both. In his country (U.S.A.), the Jeffrey chain-breast machine was employed with profit and convenience in room-and-pillar working, to a greater extent than any other type of mining-machine or method of mining. The fact that the Jeffrey chain-breast mining-machine could be used to advantage in almost any height of coal and cuts in coal, in seams where there was pyrites, in slate, and in moderately hard fire-clay made it a particularly profitable machine throughout a wide range of conditions. He (Mr. Jeffrey) did not wish to take the stand that the longwall method of working could not often be adopted with profit, but he thought that where the bord-and-pillar system was now used the chain-breast machine could be adopted with very much less outlay and more profit than if the bord-and-pillar system were converted into the longwall method of working.

He (Mr. Jeffrey) agreed with Mr. R. Hood Haggie in what he stated regarding the relative merits of the disc-longwall machine, and the much greater superiority and general usefulness of the chain-breast machine. Especially was this true in bord-and-pillar working and in the driving of entries. As a matter of fact, experience, in the United States, showed that from 350 to 400 breast-machines were used to 1 longwall machine, and there were practically no mines with a thickness of coal from 18 inches and upward in which breast-machines could not be used successfully. This being the case in his country (U.S.A.), he was led to believe that they would also prove successful in the stall-and-pillar mines referred to in Mr. Walker's paper and the accompanying discussion.

* *Trans. Inst. M.E.*, 1903, vol. xxvi., page 347.

Mr. HERBERT A. JONES (Bradford) said that there was no harder work to which an electric motor could be applied than a coal-cutting machine. The inventor of the coal-cutting machine made his coal-cutter, and then thought about a motor; and, as a consequence, the dimensions allowable for the motor were very small, considering the power. A great point was made of the fact that the motor-carcase must not be very deep; and this practically left the designer no other choice than to use a four-pole field in the motor, with two poles which carried the winding and two consequential poles, at the top and bottom.

One of the most frequent causes of breakdown in coal-cutter motors had been the breakage of the wires between the commutator-lug and the actual armature-winding, and this had been traced to two causes:—(1) The fringing effect or stray magnetic power of the field, which had the effect of causing these wires to be constantly subjected to a racking motion, owing to the commutation while in this field; and, in time, the wires became crystalline and broke. This cause, due to the fringing effect, had been obviated by the use of flexible connections between the armature-windings and the commutator-lugs. And (2) there was relative motion between the armature and the commutator: in other words, the old method of building up the armature was to key the core to the shaft, and then to key the commutator to the shaft; but, after the hard work required of coal-cutter motors, very often it was found that the keys had worked slightly slack, and that the motion consequently produced had the effect of breaking the wires. This had been overcome largely in the present machine, in which the armature and commutator were mounted on one bush and one key on the shaft. He believed that 75 per cent. of the failures in electric coal-cutting machines arose from vibration.

As to whether the bar- was better than the disc-machine or *vice versa*, he thought that it depended upon which machine got first into the pit: for his experience showed that people would buy their experience, and make their experiments with their first machine—whether it had a bar or a disc. At many a pit, coal-cutting was condemned, simply because the engineers at that pit had not taken the trouble to understand the requirements of the machine. If, after such an experiment, another type of coal-cutter was introduced, although it might be possibly

a worse machine, it would get better treatment: and probably better results would be obtained from it, simply because their experience had been gained through the previous one.

Mr. S. F. Walker (Bath) said that in the early days of coal-cutting by electricity, and in the early days of the application of electricity to motive power generally in mines, many electrical engineers took very rosy views of the power required. He had seen a machine with a 12 horsepower motor intended for coal-cutting; and only recently he saw a machine adopted to be driven by electricity, which in his view required 50 horsepower, but it was fitted with a motor of 25 horsepower. This kind of thing went on until, by trial and error, manufacturers found that cutting machines required considerably increased power. Manufacturers were understanding their work better, the men who were using them also understood their requirements better, and therefore they were gradually approaching success. Had Mr. Walker experienced any trouble with the bar-machine owing to the dirt getting on to the oily surface of the bar and working back into the gearing owing to the reciprocating motion?

Mr. A. S. E. Ackermann (London) wrote that Mr. Walker's paper contained much precise information, and was therefore very useful, but there were two points to which he would very briefly refer:—Mr. Walker stated that coal-cutting machines would be a waste of money if used for working seams by the bord-and-pillar system.* This was entirely contrary to American experience, where over 90 per cent. of the coal that was cut by machines was cut on the bord-and-pillar and not on the longwall system. Further, he stated that a "tapered bar consumes 5,833 watts or 7·77 horsepower per square foot of area holed."† This statement was erroneous, as the work done to undercut a horizontal area of 1 square foot must be expressed as a quantity of work, and not as horsepower, which was merely a rate of doing work. The rate of undercutting in square feet per hour, and the work done per square foot of undercut, were both most useful figures, and he trusted that Mr. Walker would express this matter more clearly.

Mr. John Colley (Indwe Collieries, Cape Colony) wrote that Mr. W. Walker's paper dealt with the subject from the

* *Trans. Inst. M.E.*, 1903, vol. xxvi., page 347. † *Ibid.*, page 356.

unpalatable, but very necessary, standpoint of showing frankly the difficulties to be overcome. In the introductory paragraph, Mr. Walker stated that coal-cutting machinery could not be profitably applied where the bord-and-pillar system is worked. He would point out that a large proportion of the coal that is worked by machinery is produced from bord-and-pillar districts, in the United States of North America for instance. At the mines under his (Mr. Colley's) management, a trial was made with a disc-wheel machine in longwall-faces upwards of 300 feet long, and with a chain-breast machine of American make, in 60 feet bords or rooms, and the latter system was adopted, 12 machines of this type now being at work. He would here comment on the electrical difference of the two types, which affected the selection of the machine to be adopted. The British machine had the armature wound in a theoretically beautiful manner, after the Flynn design. This method is excellent so long as the armature keeps in order; but the slightest defect necessitates the armature being returned to the makers, while the chain-breast machine is fitted with a simple ring-wound armature, which can be repaired expeditiously and cheaply at the colliery. If makers would place simplicity before theoretical electrical efficiency, they would receive many additional orders.

Mr. W. Blakemore (Montreal, Canada) wrote that Mr. Walker, in his paper, cited five reasons why coal-cutting machinery could not be profitably applied to all coal-seams at present being worked. Anyone who had followed this subject closely for the past 30 years must already have realized that the conditions under which such machinery could not be used were being constantly modified, and that the remarkable development in adaptability, taken in connection with the fact so correctly stated by Mr. Walker, as to the increasing indisposition of coal-miners to engage in the undercutting process, would at no very distant day determine the universal application of machinery. In pursuance of this object, puddling and shingling by hand had been superseded in the iron-works by mechanical appliances, and he was convinced that the very force of circumstances would compel the universal application of coal-cutting machinery for the same reason. He thought further that Mr. Walker's five reasons would be modified before long, but

at the present time probably four of them would stand. With respect to one, however, he must beg leave to differ respecting (4) "seams worked by the bord-and-pillar system." Mr. Walker appeared to be unaware that some of the best work done on the American continent had been effected in mines worked upon this system. Practically all the coal-cutting machinery used in Canada was of the percussive type, which was used exclusively in this system of work, and had produced the most satisfactory results. He had not the data before him, but from experience in the United States he was convinced that at least 75 per cent. of the machine-cut coal was also produced by percussive machines. It must be admitted that the longwall machine was more economical where it could be used, mainly due to the fact that this machine must of necessity do more undercutting in a given time under the same conditions than the other type, but natural conditions precluded the possibility of extensive longwall working in the United States and Canada. This was due largely to the fact that the bulk of the coal was worked from mountains, above surface-level, and the weight of the overlying strata was so great that longwall was impracticable. His experience led him to the conclusion that, as between a longwall machine, and a percussive machine working in rooms, there was a difference in cost of operation, in favour of the former, of 3d. per ton; but this was discounted to some extent by greater cost of maintenance. Under favourable conditions, coal could be mined from a seam 6 or 7 feet thick, by a longwall machine, at an operating cost of 2d. per ton. The actual cost of working in a similar seam on the bord-and-pillar system, and using a percussive machine, would be 5d. per ton. In consequence of the greater portability and adaptability of the percussive machine, he though it not unlikely that it would in many cases supersede the other, and to his knowledge it had already done so where foreign material, such as ironstone-balls or pyrites, existed in the coal. These were most destructive to the longwall machine, but had little effect upon the percussive, as the operator could work around them and so avoid any damage to his machine. He thought that Mr. Walker did not sufficiently grasp the variety of conditions under which coal-cutting machinery might be profitably employed. For instance, Mr. Walker considered that it would be an advantage in "new collieries with thin seams, that is, 3 feet thick and

under, with a fair roof and hard or soft holing." The most profitable application of machinery to coal-mining in Canada at the present moment was in the wellknown Phelan seam of the Dominion Coal Company, which was from 7 to 8 feet thick. with a rock-roof and a rock-floor.* From actual tests, he considered that Mr. Walker's estimate of the amount of work which could be done by machines was fairly accurate. He would like to supplement Mr. Walker's figures on disc-machines, by stating that the percussive machine in the hands of an average operator had cut in a hard seam of coal, containing pyrites, 100 lineal feet by 6 feet in depth per day; this represented four rooms in a mine worked on the bord-and-pillar system. After describing the unsuccessful attempt to cut coal at the New London collieries by means of the disc-machine, and later by the Hurd bar-machine, Mr. Walker concluded that there was no machine on the market which could be successfully applied to this seam as then worked, but he (Mr. Blakemore) could not agree to this. The percussive machine would undercut readily in a hard fire-clay floor, without reducing the coal to slack; and, as a matter of fact, a large percentage of the coal cut in the United States by percussive machines is undercut in fire-clay. He would have no fear as to the result of using an Ingersoll-Sargeant machine in the seam described by Mr. Walker.

The practical conclusions drawn at the end of the paper as to road-laying, cutters, position of coal-veins, etc., were evidently the result of experience, and appeared to be correct. He thought that at the present stage it was safe to affirm that the machine likely to become most popular was the one which, whilst perhaps not producing the largest tonnage, would give the least trouble, and was least likely to break down. In these respects the percussive machine undoubtedly bore away the palm, and he questioned whether in the long run the actual saving, as compared with hand-labour, was not as great as in the case of the larger machine. There could be no better demonstration of the value of the machine which he advocated than the fact that the Dominion Coal Company had now used it successfully for nearly ten years, had largely increased the number of machines in operation each year, and was at the present time producing 75 per cent. of their output by its aid. He was sure that on application this com-

* *Trans. Inst. M.E.*, 1896, vol. xi., page 179.

pany would furnish reliable data, setting forth the results which they had attained.

Mr. H. St. John Durnford (Leeds) wrote that Mr. Walker had given the members a most interesting and instructive paper. He thought that the members ought to be grateful to him for giving particulars of a case in which, after trying two different types of machines at the New London colliery, in the Deep Hard seam, he appeared to have come to the conclusion that no coal-cutter would have been successful. It might have been supposed that with a seam, under 3 feet thick, with a good roof and a hard floor, no particular difficulty would have been experienced, but such was not the case, and Mr. Walker's experience would certainly be valuable to others. He (Mr. Durnford) had had some experience of the Hurd cutter, and Mr. Walker's experience bore out his own—that in some instances it was possible to have too long a bar, and 4½ feet would be found in most cases the most suitable length. He had never tried the parallel cutter-bar, but he could see no reason why it should not work in every case as well as a tapered bar, such as were usually employed; and it would probably prevent what the writer found to be the case, that with a tapered bar the dirt or parting, in which the undercutting was usually made, became jammed fast and prevented the coal from breaking off to the back as freely as might be expected when a greater thickness was removed. The importance of making all cutters when first inserted into the bar project uniformly could not be too much insisted upon, but considerable difficulty was often found in this respect, and it was a matter of time sometimes to find cutters which would fit accurately and project evenly. A good plan was to fasten the cutters by driving them into the bar together with a small piece of copper-wire which acted as a wedge. Well-sharpened cutters were also a necessity. He (Mr. Durnford) believed that there was a future for the Hurd coal-cutter, and with tender coal undercut at the bottom, considerable difficulty had been caused when using a disc-machine with a large cutter-wheel, by the holed coal falling upon the wheel in large blocks and jamming the cutter-wheel. It was, of course, a much simpler matter to "sprag" close up to the bar in a Hurd machine than with a disc-machine with a wheel of large diameter. Mr. Walker's experience as to road-

laying for an undercutting bar-machine taking more time and requiring to be more carefully done than for a disc undercutting machine was not his experience. In both cases, care was necessary if delays from getting off the road were to be avoided, but he would have arrived at rather the opposite conclusion to Mr. Walker in this respect. At the same time, his (Mr. Durnford's) experience had been gained principally from flat or nearly flat mines. In his opinion the proper system, in new mines at all events, where no compressed air was available, was to use the three-phase system of alternating-current electricity, whereby any sparking at the motor was reduced to a minimum, and the risk of an accident due to the use of electricity at the coal-face was considerably lessened.

Mr. Arthur Hall (Pelsall Collieries) wrote that he had read Mr. Walker's paper with great interest, having himself successfully worked three electric Goolden-Atkinson bar-machines in a seam, 3¼ feet thick, at the Pelsall collieries for the past 6 years. These machines closely resemble the Hurd machine in general principle, except that the bar had not the reciprocating motion. He did not understand why Mr. Walker should limit the thickness of the seam for coal-cutting to 6 feet, inasmuch as existing types of machines could easily be adapted for work in seams exceeding that thickness, with the result of an increased percentage of round coal. Mr. Walker seemed to have experienced some difficulty as regards the road-laying. At Pelsall collieries, the system was very simple and economical:—Steel-rails weighing 26 pounds per yard-section were used, 1¾ inches deep and 1½ inches on the face, and in lengths of 6 and 8 feet. The ends were rounded off and drilled with holes, $\frac{15}{16}$ inch in diameter, these dropped upon studs, $\frac{7}{8}$ inch in diameter, which were rivetted into iron-sleepers, 3½ feet long, 6 inches wide and ⅜ inch thick. There were three pairs of studs on each sleeper, the outside pairs being to the machine-gauge of 28 inches, and an outside pair and the inside pair, to the tub-gauge of 21½ inches (Figs. 8, 9 and 10, Plate X.). After the cutting was completed, the outside rails were taken off the outside studs and dropped upon the inner ones, thus forming the tub-road for loading out the coals. This system had proved satisfactory, and scarcely any special spragging had been found necessary for the cutting, the

only special care needed being in the firm and equal bedding of the sleepers.

As regarded getting back the machines to the starting-point, he found (when only cutting in one direction, and before introducing the double turntable) that doing this along the face was both quicker and more economical than flitting the machine. He might also remark that he was rather surprised to learn that the weight of the Hurd machine for a cut of only 4 feet was 60 cwts. Did this include the weight of the bar? The Goolden machine weighed barely 40 cwts., including the 5 feet bar, which made a cut of 4½ or 4¾ feet. He found that in this system of bringing the machine back along the face, it was only necessary to regulate judiciously the lengths of the stalls (that is, the distance between the gate-roads) in order to secure a fairly uniform daily output. With the double turntable, however, the machine was enabled to cut both ways; but in cutting back it was, of course, necessary to use a bar with the cutters set in the reverse way to that used when cutting forward. He might here ask in passing which way Mr. Walker ran his bar, that was, the direction of rotation of the bar, whether clockwise or counter-clockwise? He had found that the counter-clockwise direction was decidedly the best, and that cutting in that direction tended to lessen vibration, by keeping the machine down more firmly upon the rails, and moreover the bar cleaned out the holing-dirt more efficiently. The arrangement was that the bar was capable of being moved horizontally through a semi-circle (or 180 degrees instead of only 90 degrees as was the case with the single turntable previously used), and this of course necessitated the machine being turned end-for-end, at every cutting of the length of face on which it worked. This seldom occupied over 1 hour, the machine being not quite 8 feet long over all, while the Hurd machine was 9½ feet long. He might mention that in these operations of getting machines along the face, and turning them end-for-end, he had found the Sylvester pulling-jack a most useful tool.

The system of starting, at Pelsall collieries, was for the bar to point itself into the face, the end of the bar passing through an arc of 90 degrees from the face to the back of the holing, whilst the machine was standing: the machine then advanced. No advance-heads were driven or slots cut to receive the bar,

and it only required the small triangular piece of coal left in to be removed by hand and dressed square, for the next pointing-in of the bar. This was done very cheaply. As regarded the fixed position of the bar when cutting, his experience proved that to produce the most satisfactory results, the bar should lie back a little, or at an angle of about 95 degrees with the front of the machine. Mr. Walker did not mention this matter, which in his opinion was very important. The parallel cutter-bar was certainly an innovation, and probably a step in the right direction, but, as regarded periphery-speed, it must be borne in mind that towards the end of a taper-bar, where this was lowest, the least thickness of cutting had to be done. He could not yet fully understand the decrease of power taken in driving the parallel bar, the larger size of the holing-dirt, and its readier removal, and it would be most interesting to know how this bar behaved in future, with different detail as regards length, diameter, form of cutters, pitch of cutters, direction of rotation, power taken and results obtained.

The form and pitch of the cutters were, in his opinion, important matters, and would be found to want varying to suit the holing of different seams. To obtain the proper form of cutter, a good plan was to have several different types placed in sections on the same bar; it would then be seen which type failed first, when running. To ascertain the most suitable pitch of the cutters, it was desirable to try several bars with cutters placed at different pitches, until the most suitable one was found. He had found a $\frac{7}{8}$ or 1 inch pitch to suit tolerably hard holing, but he had worked bars with a pitch of only $\frac{5}{8}$ inch. The above-mentioned tests should be even more conclusive with the parallel bar than with the taper bar, according to Mr. Walker's results. It would be interesting to know how long parallel bars would stand without breaking, most probably close to the collar, where bolted on to the cutter-shaft of the machine; and it might be mentioned that Mr. Walker did not state of what material the bars were made. After exhaustive trials, he found that good wrought-iron (forged) bars stood the longest. He had tried several shapes and arrangements of trailing-cleaners, but he found that none of them were satisfactory. They all absorbed much power without a corresponding efficiency, and, rather than have 30 per cent. of the dirt removed by the cleanser and 70

per cent. by hand, he would dispense with the cleanser, and remove the whole of the dirt by hand. He had had this removal done efficiently by only two men behind the machine, who had also to look after the spragging and timbering. There was certainly scope for invention; say, an automatic cleaner, taking out practically the whole of the dirt with a modern consumption of power, and saving at least one man behind the machine.

Referring to Mr. Walker's remarks on the changing of cutters, he recommended that, instead of doing this in the pit, several spare bars fully rigged up should be kept close at hand in the pit, and, when necessary, the bar should be changed as a whole, instead of the cutters. These should be replaced on the surface, where daylight admitted of a better job in their setting. To change a bar was only a question of a few minutes, whereas according to Mr. Walker, it took an hour to change the cutters in the pit (of course the time taken would be proportional to the number of cutters in the bar), and the cost of a few spare bars and cutters was comparatively small. He should like to have all the details of the parallel bar, as he had found that the section of bar used had much to do with the result. He had tried them of various sections, namely, plain round (Figs. 11 and 12), spiral round (Fig. 13), plain square, with the corners removed (Fig. 14), plain cross section (Fig. 15), and spiral cross section (Fig. 16, Plate X.), but all tapered. The two latter were drilled through the rib to receive the cutters, which, when in position, rest upon the next rib, thus giving greater strength where most needed. He had obtained the best results at Pelsall collieries with the plain square-section bar, with the corners removed. They had run for several years without breaking (the plain-round bars were frequently breaking), and they cleaned the holing much better than round bars. It would be noted that in the square bar there was much more support for the cutters round the shank than in the round (A, A, Figs. 11 and 14), and in hammering in the cutters, a crack (leading to subsequent breakage) was much more likely to be started in the round than in the square bar. He therefore suggested that Mr. Walker should try a parallel bar of this section.

With respect to cutting down-hill, he failed to see why this should not be done equally as well as cutting up-hill. He sug-

gested that a drum should be fixed on the back-end of the machine, similar to the hauling-drum on the front-end, with a similar small wire-rope passing round a pulley attached to a fixed prop some little distance behind the machine, and thence back to the drum; in fact, in every way similar to the front hauling-gear used when cutting up-hill or on the level. By this means, the machine could be regulated down to its cutting, and it could be manipulated either by the man behind the machine or it might be so arranged that the driver in front could work it.

Much had been said in comparing bar- and disc-machines. To his mind, in the majority of cases, the bar-machine was the more suitable, and he was convinced that it only wanted to be better known, to ensure its much greater use than at present. The advantages were:—(1) It could be made to cut either at the floor-level, or at the top, or in any intermediate part of the seam. (2) In the case of a seam with a bad roof, or where the coal had a tendency to come off, or fall on to the holing, timber or sprags could be set close to the bar, and only a few inches away from the actual holing. (3) The vertical height of the bar could be varied through several inches whilst cutting either for inequalities, or so as to pass obstacles in the holing. (4) It removed more material in the cut than a disc-machine, and the slot, being cut tapered, caused the coal to fall better, and, in the case of cutting in a band, say 6 to 9 inches thick, between two coals, it removed the bulk of it. (5) The bar pointed itself into the holing, and did not require any head to be driven, or slot to be cut for it to start in. (6) A bar was much easier to move and to manipulate in a thin seam than a disc, even though the latter be made in halves. (7) The bar ran at a much higher speed than the disc, was not so liable to stick, in the majority of cases, it required less power, and the load was more uniform. The results in Mr. Walker's case he considered were fairly good, but he thought that the power was rather excessive for a cut only 4 feet deep (was the cleaner used all the time?), as also were the weight and the length of the machine. The loss of voltage between the generator and machine was too great, and here he might mention that the main cables and those in the roadways, etc., could not be examined too often, or kept in too good a condition.

Mr. Walker's official report-forms were excellent and com-

prehensive.* Mr. Walker did not go very far into costs, and did not state what was saved by machine-cutting over hand-holing, etc., but this was scarcely to be expected in a published paper. It would be of interest, however, to know the rate of wages paid to the machinemen. He supposed that all the labour employed was paid day-wages. It was very difficult to set this work by contract, on either yardage, or partly day-work and a bonus on yardage over a certain amount. The tendency was for the men to scamp the work, and the extra supervision needed more than counter-balanceed any advantage gained by contract-work. The system that most commended itself to him, was to select a reliable man to drive the machine, and to let him contract for all work connected with the machine at so much per yard, with a bonus over a certain yardage, letting him pay and have charge of his own men and be responsible for the cutting being satisfactorily performed, but, at the same time, to be under the control of the deputy in charge of the district.

In conclusion, he might remark that he did not always like new departures in the way of machinery to run satisfactorily right away at the start. Very often when this was the case one did not find out the weak points until, perhaps, a big smash occurred. Now, he did not wish to predict this in Mr. Walker's case, but he did think that a little longer experience with the new bar and the details would probably produce even better results than those hitherto obtained, and he for one should be very gratified to again have Mr. Walker's experiences at the end of, say, 18 months or 2 years.

Mr. Sam Mavor (Glasgow) wrote that Mr. Walker's paper came very opportunely at a time when the subject was engaging the serious attention of so many managers who had had no practical experience of it. Papers devoted more or less to

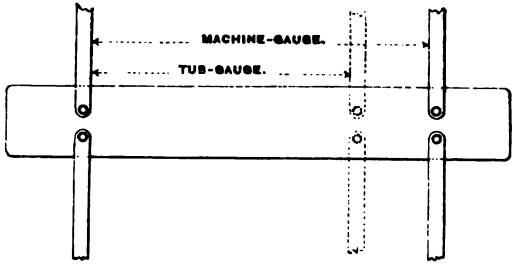
* Coal-cutting Machine-Driver's Report, Pelsall Colliery.

Face to be cut .....
Machine down at..... .m., commenced cutting at..... .m.
Delays: Cause, and how long the machine stood each time.
.....
Cut to.....
Finished cutting at..... ..... .m. Number of yards cut.....
Remarks:— .....
.....
.....day night,..... .....190....

Signed .....

RAILS AND SLEEPERS.

FIG. 8.—PLAN.



Not Drawn to Scale.

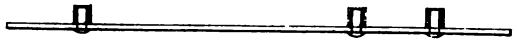


FIG. 9.—SIDE-ELEVATION.

FIG. 10.—END-ELEVATION.

CUTTER-BARS.

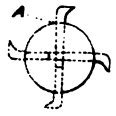


FIG. 11.

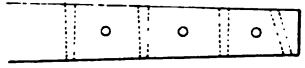


FIG. 12.—PLAIN-ROUND.

Not drawn to Scale.

CUTTER-BARS.

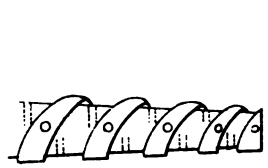


FIG. 13.—SPIRAL-ROUND.

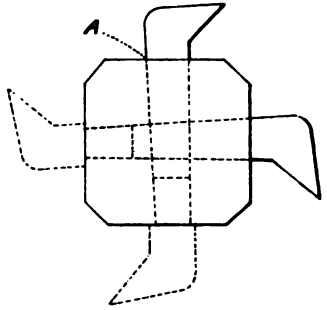


FIG. 14.—SQUARE, WITH CORNERS REMOVED.

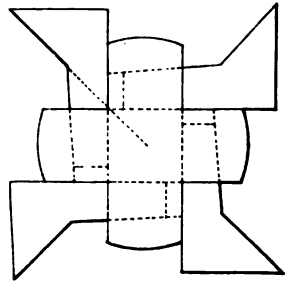


FIG. 15.—PLAIN CROSS-SECTION.

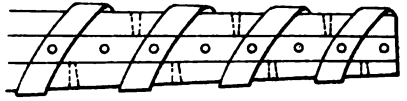


FIG. 16.—SPIRAL CROSS-SECTION.

Not drawn to Scale.

And.ᵂ Reid & Comp.ʸ Ltd. Newcastle on Tyne.

descriptions of coal-cutting machines with suggestions as to the best method of applying them had been read to the members by their inventors or makers. The value of Mr. Walker's paper lay, however, not in its record of ultimate success, but in the frank avowal of the difficulties encountered and the means adopted to surmount them. Table II. would repay very careful study, as it covered three months' working from the start, and the recorded interruptions to the progress of cutting were:—22 during April, 8 during May, and 5 during June. The last number did not include four stoppages due to cutters, which were, however, incidental to the adoption of the parallel cutter-bar. The number of interruptions in each successive month showed a very satisfactory diminution, and indicated (1) the elimination of initial difficulties due to face, road, cutters, etc., and (2) that the men were becoming more expert in handling the machine.

The question of the relative advantages of the tapered and parallel cutter-bar was very interesting, and Mr. Walker had clearly demonstrated the superiority of the parallel bar in the Tupton seam, but the statement for equal work performed that the parallel bar absorbed 40 per cent. less power than the tapered bar must be due to an error of observation or some cause affecting the accuracy of the test, as this statement was inconsistent with the averages of the records shown in Table II. On examining closely into Table II., he found conclusive evidence that the comparatively poor results obtained during April, that was the first month of the working of the machine, were chiefly due to the volts being too low for the motor. After the volts were raised to the pressure for which the motor was wound, a comparison of four consecutive cuts with the tapered bar from May 11th to 14th with four consecutive cuts with the parallel bar from June 19th to 23rd, showed that the average power absorbed in the former case was 7,300 watts per square foot cut and in the latter case 6,500 watts per square foot cut, a saving in favour of the parallel bar of little over 10 per cent. and not of 40 per cent. as stated in the paper. During both of the periods taken for comparison, the machine was described as doing well.

Mr. Walker raised a very important point in referring to the peripheral speed of the cutters, but he (Mr. Mavor) disagreed with the opinion that the harder the holing the greater should be the cutting speed. This was quite at variance with general

practice in the use of cutting-tools, to the effect that the softer the material the higher may be the cutting speed. As the holing was harder near the point of the bar, the tapered bar with a lower speed of cutters seemed to have, from this point of view, the advantage. The difficulty experienced by Mr. Walker was due to the cuttings not being properly brought out from the point of the bar, and this could certainly have been alleviated by increasing the depth of the thread of the worm and thus increasing its capacity as a conveyor. Mr. Walker's own suggestion, however, to use a parallel cutter-bar went to the root of the trouble and successfuly overcame it. It by no means followed from the success of the parallel cutter-bar in the Tupton seam, that it was adapted for general work. On the contrary, the tapered cutter-bar worked satisfactorily, and with a very low consumption of power, and was generally preferred, owing to the fact that the tapered undercut gave the coal a forward fall instead of dropping directly down as it did in the case of the parallel-cut holing. The tapered cut also made less small when holing in coal.

Another interesting suggestion of Mr. Walker's was that the cutters should be arranged spirally, so that the work done during a revolution of the bar was more uniformly distributed. This method of fixing the cutters was formerly used, but departed from, so as to permit of the more ready inspection of cutters when fixed in straight rows. As Mr. Walker pointed out, the spiral arrangement had many advantages when holing in hard material.

The chief interest of Mr. Walker's paper seemed to lie in its illustration of the fact that success in cutting coal could only be obtained by the active and intelligent interest of the management, and the exercise of energy and resourcefulness in surmounting the initial difficulties. The introduction of coal-cutting machines was rarely a straightforward matter; there were always considerable difficulties to be overcome; and the best machine in the world was useless if conditions favourable to its working were not provided, especially with respect to a straight face and good road. When everything external to the machine was in order, the machine must needs be adapted to the conditions of each particular case. The most suitable shape of cutters, the best depth and best thickness of cut, the best rate of travel and other such matters, could often only be ascertained

by experiment in each individual case. Exceptional difficulties might also arise, as at New London colliery, where a modification of the machine was required to adapt it to the special conditions. The manufacturer would always be found ready to co-operate and to render assistance when troubles arose, but with a machine of suitable type, capable of doing good work, it remained with the colliery-manager to achieve success in its application to his own seam. It was useless to put a machine into a pit, unless the manager was prepared to take a personal interest in it and to do his utmost to make it go; and it could not go without his assistance.

With regard to the output per man employed on the working-face, he asked Mr. Walker whether he was correct in deducing that with the machine the output per man was approximately doubled.

Mr. Walker's paper was extremely valuable, as it set forth an unvarnished account of his experience in introducing coal-cutting machines under somewhat difficult conditions, and the record of difficulties encountered and removed should encourage others to do likewise. It was worthy of note that, during the 3 months covered by the detailed reports, there was no stoppage nor interruption due to any breakdown of the machine, notwithstanding that it must have been subjected to exceptional strains before the parallel cutter-bar was fixed.

Mr. W. Walker, replying to the discussion, stated that there had been no electrical breakdowns, except those which occurred with the disc-machine. They sometimes ran the previous machines when receiving about 90 ampères, and in one case—with the Scott-and-Mountain machine—120 ampères. The number of men employed in connection with each machine differed very much at different collieries, but they must put down to the machine what they would put down to hand-holing. They could cut with 3 or 4 men, but the next day they would have to set other men to remove the dirt. In their special case, they perhaps required one man more than any other machine. It was important to get the men to see that the machine was kept in one particular plane. In the near future, they would raise and lower the machine from the place where the driver worked the switch and by this arrangement one man's services

would be dispensed with. With respect to the parallel bar, very fortunately he did not take the ampères himself, but he allowed Mr. Hurd, who was at first somewhat prejudiced against the parallel bar, to do so, and that gentleman saw the great reduction of power required as compared with the tapered bar. Probably one reason was that the machine was supplied with bars which had been partly worn out by somebody else. He thought that the solution with regard to the reduction of small holing dirt was due to the increased speed just at the point where it was required. In a mechanical shop, they would say that if they met with something hard the speed must be reduced, and that would naturally be done at a lathe, with the result of course that it would take a longer time to do the work. But where they were only working at dirt, there was no consideration for slowing down; and he thought that this was one reason for the parallel bar answering better. He thought that 4 feet was the longest parallel bar that would work efficiently at the time, since then he had ordered bars of various lengths, and he was now using a 4½ feet bar successfully, but he could not anticipate using a longer bar, unless the holing became softer. The bar had been adopted in place of the disc-machine, because the disc was found to be frequently rising into the coal. Another reason was that with the disc-machine the greatest distance guaranteed was 40 yards per shift, which in a thin seam was not very much; the bar could cut a much greater length, and had done so ever since its introduction. With respect to cutting in the bar at the commencement, it was possible if there was a soft holing, but the maker of the bar did not advise them to do so in their case. If they set a large number of cutters to work all at the same moment, it would have a retarding influence on the machine; but by bringing them on gradually, as in the spiral bar, they got as uniform a cut, and a saving of power. The bar was round, and threaded at 5½ inches pitch, the thread being ⅞ inch deep. With reference to the question of loading on the same rails: they broke in at the gate-ends and loaded straight forward with the rails used for cutting with the machine. When a large ironstone-ball, such as shown by photograph, was met with, they simply racked the machine above the ironstone-ball, and after it was passed they cut down again. They had had no trouble from dirt getting into the gear-case. The machine had

been worked rather more than 5 months, and there had never been a breakdown. When examined last week, the gear-wheels were found to be so little worn that it was scarcely evident that they had been working.

In reply to Mr. Holiday, as to the number of men engaged at the machine, 3 men are employed in working the machine, and other men must be employed to clean out the dirt, as no machine, as at present arranged, can clear out all the dirt. To drop the coal on the dirt left under the coal would decrease the market-value of the coal, and it would still have to be removed before the rails could be laid for the next cut made by the machine. Possibly, Mr. Holiday paid 1½d. or 2d. per yard for cleaning out the dirt, an amount usually paid, in some districts, to the stallmen or loaders. No extra payment is allowed at his collieries.

Mr. Colley drove his bords 60 feet wide, perhaps, to enable the machines to be profitably employed, but the cost of removal must be excessive.

He (Mr. Walker) had received an offer from the representative of the Ingersoll-Sargeant machine, who guaranteed to cut 14 yards per shift, but the initial expense of providing two machines and an air-compressor was £550: this enormous cost for 28 yards per shift was very much in excess of the cost of the present arrangement.

Mr. Hall's suggestion that spare bars should be kept at hand to replace each other, when cutters required changing, would be most expensive. The extreme time, 1 hour or more, referred to a complete change of cutters, whereas in three changes out of four, probably not half of the cutters required changing, and the time taken was proportionately less. The cost of replacing a cutting-bar, which weighed nearly 3 cwts., in a thin seam, midway between the gate-roads, would be very great, and prohibitive to the use of the machine. The bar worked in a clockwise-direction, when looking over the machine. The output per man was rather more than double of that produced by hand-holing.

A little difficulty was anticipated in removing and replacing the parallel bar, but the slightest difficulty had not yet been experienced.

Mr. Bulman asked why the wheels, fixed on the machine, were not of the same gauge as the roadways. This was thought of, but

an examination of the machine proved that it was almost impossible at the particular points at which the wheels must be fixed in order to balance the machine. The idea of using larger wheels was good and workable, especially if the machine was only required to cut in one direction. The machine was tilted, or otherwise, when tilted by the screw, it would be working with the screws nearly run out.

Mr. Haggie referred to the Jeffrey machine at Gedling colliery; but, on making enquiries, he found that it had not been at work for some months, as the holing by the machine was not so rapid as that done by hand.

Mr. Liddell asked whether teeth had ever been tried on the thread. Teeth had been tried on the thread at the commencement of the 4½ feet bar, where the teeth were arranged spirally, and they were found to bring out too much dirt and thereby reduced the yardage cut. He (Mr. Walker) was of opinion that, where the holing was somewhat soft and at least 8 inches thick, this arrangement would bring out practically all the dirt to the front. With regard to the running of the machine back along the face, this, with them, would be impossible, as three nights were required to cut the face, meanwhile the loading, packing, etc., was proceeding; this formed the face into a series of steps, and therefore made it impossible for the road to be laid for the machine.

The horsepower, when running empty and loaded respectively, had been tested when cutting to a depth of 4½ feet, as follows:—(1) Running empty, but including resistance of cable, 12 ampères at 480 volts, or 7·6 horsepower; and (2) cutting with sharp cutters, 45 ampères at 480 volts, or 29·8 horsepower.

The CHAIRMAN (Sir Lindsay Wood, Bart.) moved a vote of thanks to Mr. Walker for his interesting paper.

Mr. J. T. TODD seconded the resolution, which was cordially approved.

Mr. FRANCIS FOX read the following paper on "Rapid Tunnelling":—

RAPID TUNNELLING.

By FRANCIS FOX, M.Inst.C.E.

Introduction.

Tunnels.—The question of rapidity in the construction of tunnels is one in which the whole community are more or less, although often unconsciously, interested. If by the introduction of suitable machinery the time required for the execution of some great tunnel can be reduced to one-half, or one third, the loss of interest on the capital involved in the undertaking is correspondingly reduced, and thus great mountain-ranges, which a few years ago were regarded as impenetrable barriers, or rivers and arms of the sea regarded as impassable boundaries, have been conquered by the engineer.

The Mont Cenis tunnel, having a length of 7·98 miles or 42,135 feet, with a height of mountain above it of 5,428 feet, occupied 13 years in execution; the St. Gothard, the length of which is 9·3 miles or 49,104 feet, with 5,598 feet above it, required 10 years to carry out; and the Arlberg, 6·36 miles or 33,582 feet, with 2,362 feet of rock over it, all have now been eclipsed by the colossal work of the Simplon tunnel. This will be 12·26 miles or 64,725 feet in length, with a height of mountain above it of 7,005 feet. The work was commenced in August, 1898, and at the end of July, 1903, the distance penetrated amounted to 54,381 feet, in less than 5 years. Assuming the present rate of progress to be maintained, it is expected that the two headings will meet about May, 1904, thus attaining to considerably more than double the speed reached in the case of the St. Gothard tunnel.

When it is borne in mind that, under ordinary tunnelling conditions, the speed falls off as the distance from the portal increases; and that, in this particular case, very high temperatures of rock and of air and water have been encountered, the above results are remarkable, and speak volumes for the skill, the determination, and the unconquerable perseverance of those engaged in the work.

It was expected that in consequence of the mountain *massif* existing over the tunnel, a high temperature would be encountered, but this has been considerably exceeded, and it is the opinion of those well able to speak with authority that some connection exists between these high temperatures and the great eruptions in Martinique and St. Vincent. At the time of these catastrophes, certain cold mineral springs in Austria began to run hot water.

The maximum heat, which has been recorded in the advance headings from Brigue, is no less than 55° Cent. (131° Fahr); whereas on the southern or Iselle side, the great spring which was met with at $2\frac{3}{4}$ miles (4,400 metres) from the portal has no doubt acted as a refrigerator, the maximum heat attained being 37·5° Cent. (99° Fahr.)

The writer has not, however, in this short paper to dilate on questions of temperature, but upon rapid execution of work.

The introduction of machinery does not always result in increased speed; of this a notable instance occurred in a certain tunnel with which the author was connected. A heading through rock had to be driven, the distance between the portals being 6,000 feet. At one end, hand-labour was employed and effected a steady advance of 27 feet per week. At the other end, machinery was used, and so well did it do its work that occasionally as much as 201 feet a week were penetrated. Then a breakdown would occur, resulting in a long stoppage; at last when the two "faces" finally met, it was found that the advance made by the machine was exactly at the same average speed as by hand-labour, 27 feet per week.

In a recently constructed main-line tunnel, with which the writer was connected, the length being 9,000 feet, the average advance at each "face," including those from the portals and from numerous shafts and break-ups, was 1 foot 6 inches per week per "face" of excavated and brick-arched tunnel.

Tunnelling in Clay.

Greathead Shield.—The speed attained in the tube-railways of London, driven through London Clay, depends upon the diameter of the Greathead shield. The following are samples of fair average work:—

In 11 feet 8 inches tunnels, each shield leaves behind it as a naximum about 43 rings of 20 inches each, or 72 feet of finished unnel per week, but the progress does not average more than 23 ·ings. In 16 feet tunnels, 26 rings of 20 inches, or 43 feet, may ›e taken as an average week's work. In station-tunnels, 23 'eet in diameter, 19 rings of 18 inches, or 28½ feet, and in cross-›ver tunnels, 30 feet in diameter, driven by hand (and not by hield) 4 rings of 1 foot 6 inches each, or 6 feet, is good work.

FIG. 1.—PRICE ELECTRICAL EXCAVATOR.

Price Electrical Excavator.—Various attempts have been nade in the Central London and other railways to increase the ·ate of progress, and promising results are being secured by Mr.

Price's electrical excavator for clay or soft soil, of which the following description with the accompanying photograph will give a good idea (Fig. 1). This is an attachment to an ordinary Greathead shield, the only alteration being that, instead of a square opening in the diaphragm-plate it is made circular, and of sufficient size to admit of the boring-head of the excavator being accommodated. The excavator consists of six radial arms carried on a central shaft, carried on the shield by means of transverse girders, one such girder being on the diaphragm-plate and the other girder placed about 3 feet farther back. The radial arms are supported at their outer extremities by an annular ring, to which are attached also the buckets, which pick up the excavation from the bottom of the shield.

The head is revolved by a rack near the outside of the cutting edge. This rack (or race-wheel) is driven by means of a pinion, which in turn derives its power from a train of wheels driven by an electric motor; this motor is fixed on the side of the shield and underneath the transverse girders before mentioned.

The actual cutting of the clay is done by means of knives carried on the six radial arms. The excavation, after it is cut, falls to the bottom of the shield. It is then picked up by the buckets and carried to the top of the shield, where, after falling through small shoots which revolve with the head, it is discharged through a fixed shoot attached to the transverse girders.

This stationary shoot delivers the excavation on to a belt-conveyor, also driven by an electric motor. The conveyor is some 25 feet long, and delivers the excavation into the skips at about this distance from the excavator. Thus it will be seen that the excavation is not handled at all except by the machine, its course being:—(*a*) Excavation is cut out by knives attached to the revolving radial arms, and falls to the bottom of the shield; (*b*) is picked up from the bottom of the shield by revolving hoppers or buckets, and carried to the top; (*c*) is discharged at the top through a shoot, and falls on to the travelling belt of the conveyor; and (*d*) is taken by the belt, some 25 feet, and there discharged into skips automatically.

The machine is kept up to the face by means of the hydraulic rams of the shield. Pressure is supplied to these by air-driven pressure-pumps, which are only allowed to work sufficiently fast

to keep the machine up to its work. This speed can be regulated at will, so that the machine can either work at its maximum advance of 1 inch per minute, or as slowly as desired.

It will be seen that the excavator and the shield form practically one machine. The entire machine is steered in the same way as the Greathead shield, namely:—Hydraulic rams, of which there are eight; and these can either be worked all together or any number at a time, as required.

The time of cutting out a length equal to a ring of 20 inches of iron is 20 to 30 minutes, the erection of the iron taking about the same time, so that, on the average, it takes 1 hour to excavate and put in a ring of iron, as against 2½ hours taken in doing it by hand with the ordinary shield. It is expected that when the machine has been worked some time, so that the men are more used to it, they will be able to complete eight rings in a shift of 10 hours, against four (or at most five) done by hand, assuming that the grouting and the checking of the lines do not cause delay.

The number of men required for working the ordinary shield is 13, whereas with the excavator 8 men only are wanted. The work which these men have to do in connection with the excavator is pushing away skips from the conveyor as filled, putting other empty ones in their place, and cleaning up.

By means of this excavator as many as 54 to 56 rings per week have been attained, although the inevitable breakdowns and delays occasionally occur. But, as these points of weakness are eliminated and constant work attained, the speed will be further augmented, the machine itself being able to advance 1 inch per minute, and a ring of 20 inches has been advanced in 1 hour. But this would give rise to some difficulty in securing true and accurate axis-lines in the tunnel which require the greatest care in tube-railways.

A distinct improvement in the air of the tunnel is perceptible wherever the electrical excavator is at work, due to the reduced number of men, and the less arduous character of their work, probably also in some measure due to the employment of electricity.

That this machine may prove to be a thorough success is, in the interests of the engineering and contracting staff, and of the men themselves, and consequently of the tube-companies, most devoutly to be desired.

Tunnelling in Rock.

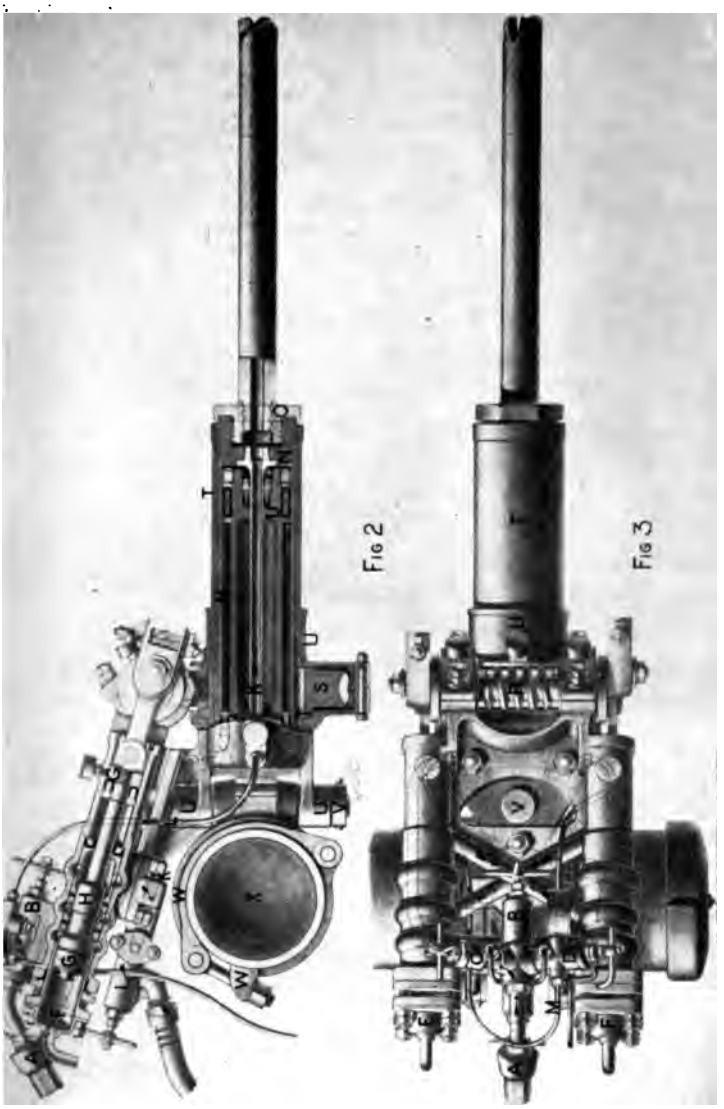
Brandt Hydraulic Drill.—Most remarkable results in rock-tunnels have been attained by means of the Brandt hydraulic drill. The late Mr. Brandt was the mechanical engineer in charge of all the machinery employed on the St. Gothard tunnel, and during the execution of that work carefully studied the requirements for producing an efficient rock-drill. He, after trying every drill under the sun, came to the conclusion that no reciprocating drill was desirable, and that dry drilling must in the interests of the workmen, and of the life of the tool, be abolished. He designed his well known hydraulic drill, which is practically a cheese-scoop on a large scale, pushed forward with a pressure of 10 tons on the cutting edge, and slowly rotated, the exhaust-water being discharged through the axis of the drill right up to the cutting-edge, thus keeping it cool, producing no dust, and washing out the débris in the form of wet grit and mud. The following description of it, a portion of which is from the paper read by the writer's son, Mr. Charles Beresford Fox, B.A., before the Institution of Civil Engineers,* aided by the accompanying photographs, may be sufficient to give the members some idea of this magnificent machine.

Method of Working.—The drilling-machines employed are of the Brandt type and are mounted in the following manner:—A small four-wheeled carriage supports at its centre a beam, the shorter arm of which carries the boring mechanism and the longer a counterpoise; and near its centre is the distributor. In the short arm is a clamp holding the rack-bar or butting column, which is a wrought-iron cylinder with a plunger constituting a ram, and is jammed by hydraulic pressure between the walls of the heading, thus forming a rigid support for the boring-machine, and an efficient abutment against the reaction of the drill. This rack-bar can be rotated on its clamp in a plane parallel to the axis of the beam. Three or four separate boring-machines can be mounted on the rack-bar, and can be adjusted in any reasonable position.

The boring-machine performs the double function of continually pressing the drill into the rock, and of imparting to it

* "The Construction of the Simplon Tunnel," *Minutes of Proceedings of the Institution of Civil Engineers*, 1900, vol. cxl., pages 249-266.

iiform rotary motion. The pressure on the drill is exerted
ıe cyclinder or hollow ram, N, (Figs. 2 and 3) revolving



Figs. 2 and 3.—Brandt Hydraulic Drill.

: the differential piston, U. The motors and pipe-con-
ons are bolted to this latter, and the whole is mounted by a
l on the rack-bar, X.

The machine is coupled to the hydraulic main by the pipe-connection, A, and water is alternately admitted through the throttle-valve, C, and the three-way cock, D, to the space in front of the differential piston, where pressure is brought to bear on the drill, projecting the ram forward, and to the annular space behind the differential piston, causing the ram to recede and withdraw the drill from the blast-hole. The motion of the ram is thus under control of the cock, D, which also connects the fore-and-aft chambers of the ram with the outlet. The pressure on the drill can be regulated as desired by the throttle-valve, C, to suit the condition of the claws and the frequent variations in the hardness of the rock.

The rotary motion and demolishing action is imparted to the drill by a twin-cylinder motor, mounted on the differential piston and frame, U, of the machine. Water is admitted by the cock, B, to the cylinders, E and F, of which the pistons, G and H, act reciprocally as valves. By means of the worm, R, and wormwheel, S, the motor drives the shell, T, which in turn engages the ram, N, by a long feather, leaving it free to slide axially under the control of the cock, D, as above described. Rotated by the motor, and under pressure of the ram, the drill bores its way into the rock, until it has reached the end of its stroke. The cock, D, is then reversed, the ram recedes, a rod is added, and the machine is ready to continue its work.

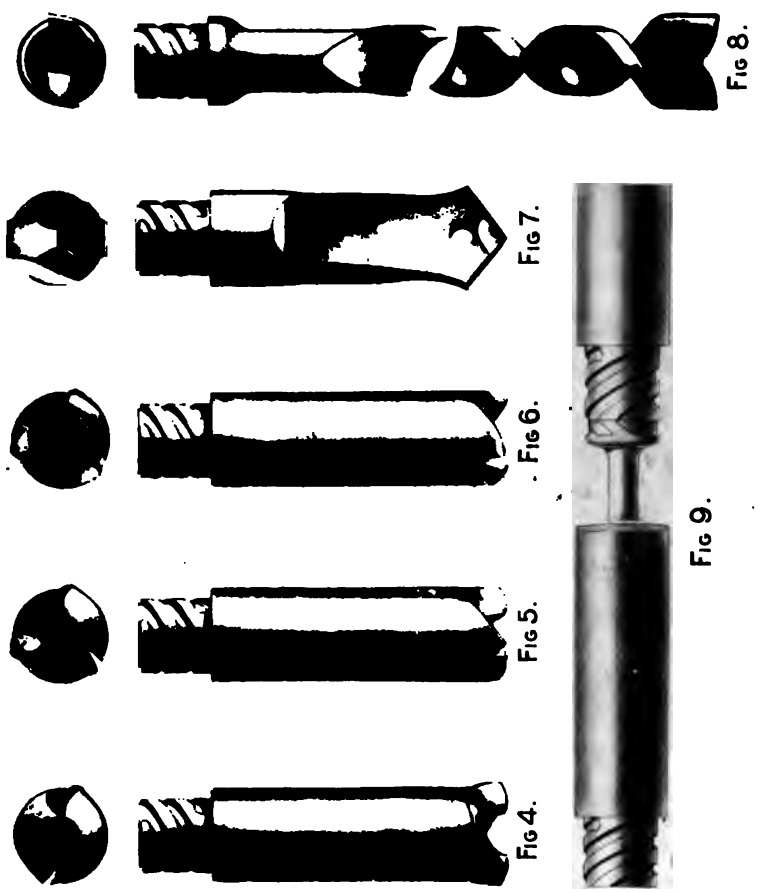
The speed of the motor depends upon the features of the rock encountered and is controlled by the inlet-cock, B.

The exhaust-water, from the two cylinders, escapes through a common outlet, but by means of the cock, I, part of it can be made to pass through the tube, K, and up the bore of the extension-rods and drill, whence it escapes between the claws of the latter, scouring away the débris and keeping the drill cool.

The ram and the motor-pistons are kept tight by leathern cups; and those of the pistons, being subject to wear, are so arranged that they may be replaced in a few minutes during blasting operations. The piston-guides, bearings, the worm and its pin, require to be lubricated. The moving parts are subject to very little wear, even when exceptionally hard work is required of them; the other parts are subject, so to say, to no wear at all, and the machine is practically indestructible.

The average speed of the motor varies from 150 revolutions

o 200 revolutions per minute, the maximum speed being 300 evolutions per minute. The loss of power between the worm nd wormwheel is only 15 per cent. at the most; the worm eing of hardened steel and the wheel of gun-metal, the two



Figs. 4, 5, 6, 7, 8 and 9.—Drills and Extension-rods.

urfaces in contract acquire a high degree of polish, resulting n little wearing or heating. Taking into consideration all other sources of loss, 70 per cent. of the total power is utilized.

The drill proper is a hollow tube of tough steel, armed with

sharp and hardened claws. It is made to rotate slowly under great pressure, the claws crushing and demolishing the rock opposing its path. The drills are armed with either 2 or 3 claws, according to the natural features of the rock (Figs. 4, 5 and 6). The extension-rods (Fig. 9) are forged-steel tubes having the same external diameter as the drill, and are made in standard lengths, of 2 feet 8 inches, 1 foot 10 inches and 11¾ inches.

When the ram has reached the end of its stroke of 2 feet 2½ inches, the tool is quickly withdrawn from the hole and unscrewed from the ram; an extension-rod is then screwed into the tool and into the ram, and the boring is continued, additional lengths being added as the tool grinds forward; each change of tool or rod takes about 15 seconds to 25 seconds to perform.

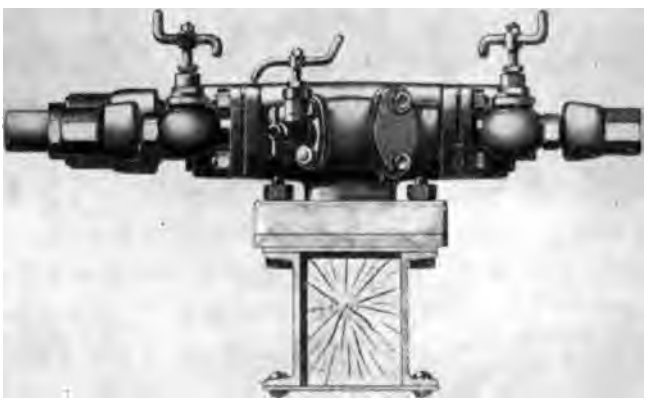


FIG. 10.—THE POWER-DISTRIBUTOR.

The total weight of the drilling machine is 264 pounds, and that of the rack-bar when full of water is 308 pounds. The exhaust-water from the two motor-cylinders escapes through a tube in the centre of the ram and along the bore of the extension-rods and drill, thereby scouring away the débris and keeping the drill cool; any superfluous water finds an exit through a hose below the motors, and thence away down the heading.

The distributor (Fig. 10) supplies the various parts of the machine and the rack-bar with hydraulic power from the mains. It consists of a hollow iron casting fitted with the necessary

ranch-pipes and cocks, and, internally, with a strainer to retain npurities. The distributor is bolted to the beam, and conitutes the termination of the hydraulic mains. There are three ocks serving respectively the rack-bar and each of the two borig-machines, the connections with the latter being effected by ieans of flexible or articulated pipe-connections (Fig. 11) which llow freedom of movement in all directions.

The area of the piston for advancing the tool is 15½ square aches, and this under a pressure of 1,470 pounds per square ach gives a pressure of over 10 tons on the tool, while for withrawing the tool 2½ tons is available. In the rock found at

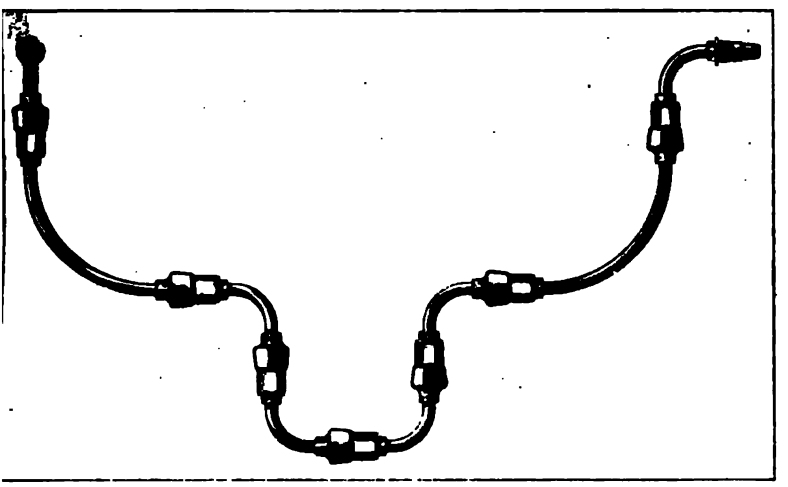


FIG. 11.—ARTICULATED PIPE-CONNECTIONS.

selle, namely, antigorite-gneiss, a hole 2¾ inches in diameter nd 3 feet 3 inches in length is drilled, normally, in 12 minutes o 25 minutes: a daily rate of advance of 18 feet to 19½ feet s made in a heading having a minimum cross-section of 59 square feet; the time taken to drill ten to twelve holes, 4 feet 7 inches deep, is 2½ hours.

When the débris resulting from one operation has been sufficiently cleared away, a steel flooring, which is provided near the face to enable shovelling to be more easily done and to give an even floor for the wheels of the drilling carriage, is laid bare at the head of the line of rails, and the drilling-machines

are brought up on their carriage by eight or ten men. When advanced sufficiently close to the face, the rack-bar is slewed round across the gallery and is wedged up against the rock-sides; connection is made between the distributor and the hydraulic main, by means of the flexible pipe, and pressure is supplied by a small copper-tube to the rack-bar ram, thereby rigidly holding the machine. Next, connections are made between the three drilling-machines and the distributor, and in 20 minutes from the time when the machine was brought up all three drills are hard at work, water pouring from the holes.

Two men are allotted to each drill, one to drive the motor, the other to direct and replenish the tool, one foreman and two men in reserve completing the gang. A small hammer is freely used to loosen the screw-joints of the extension-rods and drill. A hole is usually commenced by a two-edged flat-pointed tool until a sufficient depth is reached to prevent the circular tool from wandering over the face of the rock, but in many instances the hole is commenced with a circular tool. The exhaust-water during this period flows away by the hose underneath the motor. In the antigorite-gneiss, ten to twelve holes are drilled for each attack, three or four in the centre to a depth of 3 feet 3 inches, the remainder, disposed round the outside of the face, having a depth of 4 feet 7 inches. The average time taken to complete the holes is $1\frac{3}{4}$ hours to $2\frac{1}{2}$ hours. Instead of pulverizing the rock, as do the diamond-drills, it is found that the rock is crushed, and that headway is gained somewhat in the manner of a circular saw through wood. The core of rock inside the tool breaks into small pieces, and can be taken out (if necessary) when the drill requires lengthening.

The lowest holes, inclined downward, are full of water: consequently two detonators and two fuses are inserted, but apart from this, water has little effect on the charge. The fuses of the central holes are brought together and cut off shorter than those of the outer holes, in order that they may explode first, to increase the effect of the outer charges. All portable objects such as drills, pipe-connections, tools, etc., have meanwhile been carried back; the steel flooring is covered over with a layer of débris to prevent injury from falling rock, and to the end of the hydraulic main is screwed a brass-plug pierced by five holes, and immediately the explosions occur a valve is opened in the

tunnel and five jets of water play upon the rock, laying the dust and clearing the air. The necessity for this was shown on one occasion when this nozzle was broken by the explosion and the water had to be turned off immediately to avoid useless waste. On reaching the face, the atmosphere was found to be so highly charged with dust and smoke that it was impossible to distinguish the stones at one's feet, although a lamp had been placed on the ground; and despite the fact that the air-tube was in full blast, the men experienced great difficulty in breathing.

A truck is now brought up, and four men clear a passage in front, through the heap of débris, two with picks and two with shovels, while on either side and behind are as many men as space will permit. The stone is thrown either to the sides of the heading or into the wagon, shovelling being greatly aided by the steel flooring, which, before the explosion, had been laid over the rails for nearly 30 feet down the tunnel to receive the falling rock. These steel plates are taken up when cleared, and the wagon is pushed forward until the drilling-machine can be brought up again, leaving the remaining débris at the sides to be handled at leisure during the next attack. The roof and side-walls are of course carefully examined with the pick, to discover and detach any loose or hanging rock. The times taken for each portion of the attack in this particular antigorite-gneiss are as follows:--Bringing up and adjustment of drills, 20 minutes; drilling between 1¾ hours and 2½ hours; charging and firing, 15 minutes; clearing away débris, 2 hours; or for one whole attack, between 4½ hours and 5½ hours, resulting in an advance of 3 feet 9 inches, or a daily advance of nearly 18 feet.

FIG. 12.—BRANDT HYDRAULIC DRILL IN THE ADVANCE-HEADING.

The consumption of high-pressure water (1,400 pounds to the square inch at the compressors—and 1,100 to 1,200 pounds at the attack) varies from ¼ to ½ gallon (1 to 2 litres) per second for each drill—and the horsepower required for each drill varies from 20 to 27, according to the nature of the rock.

Full information on all these points may be obtained from Messrs. Sulzer Brothers, of Winterthur, the sole makers of these drills.

From October 1st, 1902, to June 30th, 1903, the progress made at the two "faces" was as follows:—Total advance from Brigue, 5,050 feet (1,539 metres); from Iselle, 4,610 feet (1,405 metres); or 18·4 feet (5·6 metres) per working day. If allowance were made in the above calculation for delays caused by holidays, timbering, lengthening mains, etc., the daily average would be still larger — but the progress of over 18 feet a day through hard rock hindered by high temperature, heavy feeders of water, great distance from the portals, and other causes, over a period of 9 months, is record progress. On some individual days, for instance, July 25th last, an advance of 32 feet 2 inches was attained at the Iselle face.

FIG. 13.—SPRING IN TRAVERSE XIX., IN MARBLE, SIMPLON TUNNEL.

Fig. 12 shews the drills at work in the advance-heading, and Fig. 13 shews the great spring.

Health of Workmen.—The care and consideration which have been bestowed upon the men employed at the Simplon tunnel entitles all concerned to the highest praise. The provision of dry clothing, of warm rooms for changing and bathing, the supply of good food and comfortable lodgings, are not to be equalled on any other work; and the author is of opinion that

on our great engineering works (and also in many of our mines) similar provision could be made with great advantage both to masters and men.

Notwithstanding the great distance from the open air that the advance-headings have now reached, namely, 31,595 feet (9,630 metres) at the Brigue end, and 22,638 feet (6,900 metres) at the Iselle face (a total of 10¼ miles) and the very high temperatures encountered, not a single case of phthisis has ever occurred on the tunnel, and the health of the men throughout is of the highest standard. This is due to the care displayed by the officials and contractors, and also to the absence of dry drilling in the advanced headings.

The author addressed a letter to *The Times* on October 6th, 1902, and it appeared in the issue of October 14th.* It was a curious coincidence that on the same date, an announcement

* MINING ON THE RAND.—To the Editor of the *Times*.—Sir,—I have read with much interest the articles which have appeared in your columns on the labour-problem on the Rand, and on the efforts which are being made to induce white labour to enter the mines.

It is hardly to be wondered at, especially by those who have visited the Transvaal, that difficulty should be encountered when it is known how very serious are the results which accrue to the workers.

When the war broke out, and work practically ceased on the Rand, large numbers of Cornish miners left Johannesburg and returned to Cornwall until peace was restored; and within these 2½ years, according to a statement made in the Chamber of Mines, no less than 600 of these fine stalwart men died in Cornwall from "miners' phthisis." In consequence of the dust from the percussive drills impregnating the air of the mines, and in many cases aggravated by defective ventilation, the men die off rapidly. It is said that three years is about the average period which men are able to work in the advance headings, and in consequence wages in some cases have to be paid to the leading hands of from £100 to £150 a month.

I have no doubt that the mining companies and their able managers do all they can to abate the evil, but the condition of things is very bad and demands remedy. So long as percussive drills are used, so long will this heavy death-roll take place. As an illustration of the disastrous results of dust, I may state that I was personally connected with a certain heading which was being driven by a gang of 16 miners—all fine powerful fellows—and yet within a comparatively short time every one of them died from consumption. The last survivor came to my house for some weeks, and it was pathetic in the extreme to hear him speak of his dead comrades, and to know that so soon he was also to be in his grave.

At the present time, the Simplon tunnel is being constructed through the Alps, a distance of 12¼ miles, and the advance-headings are being driven by the Brandt hydraulic drill at a most rapid rate of advance. In the month of July last, at a single "face," the drift-way, 10 feet wide by 6 feet high, was driven through very hard rock the record distance of 770 feet, or fully four or five times as much as has ever been executed in any mine in Great Britain.

One of the chief features of this drill is that it makes no dust, all the *débris* being washed away by water; and this, combined with excellent ventilation and humane arrangements for the welfare of the men, has resulted in an almost entire absence of ill-health amongst the *employés*, some 3,000 in number. A hospital is provided at both entrances to the tunnel, but beyond some inevitable cases of accident the beds are almost empty.

The Brandt drill ought to be established in all gold, diamond or copper-mines for driving the galleries; the result would be a greatly accelerated rate of progress, much reduced cost, and a marked saving in life. Whether the drill

was made from Johannesburg, which is appended, offering large prizes for the best method for suppressing phthisis.*

In the author's opinion, the hydraulic drill is the solution of the difficulty, but Messrs. Sulzer have been so busily occupied with the Simplon and other work, that they have not yet been able to devote their attention to designing a small portable drill for stoping. The narrowest heading which can at present be driven by the Brandt drill is 4 feet 11 inches (1·5 metres) in width.

In the *Western Daily Mercury*, Plymouth, on August 1st, 1903, occurs a statement which well illustrates the grave results of dry drilling.† Although "spraying," as now being tried in

could be employed in "stoping" is a matter which can be investigated on the spot, tested by actual experiment.

The only objection which can be raised against its employment is the scarcity of water on the Rand; but arrangements could be made for collecting the water, after leaving the drills, in a "sump," and thus using it over and over again.

I am, Sir, yours faithfully, FRANCIS FOX, 28, Victoria Street, Westminster, S.W., October 6th, 1902.

* MINERS' PHTHISIS.—Large Rewards offered for Remedial Appliances.—The Chamber of Mines is desirous of taking steps to obviate or minimise the occurrence of miners' phthisis, and invites practical suggestions and plans for combating the causes leading to the same. No definite information is before the Chamber as to the causes of the disease, but the general assumption is that it is chiefly due to the inhalation of fine dust given off during the machine-drilling operations.

The Chamber offers the following awards for the three best practical suggestions and devices on this subject, namely:—First prize, £500 and a gold medal; second prize, £250; and third prize, £100. In suggesting devices for attaining the object desired, the following points are to be specially taken into consideration: (1) The applicability of the device or the apparatus to the existing system of machine-drilling; (2) The practical demonstration of the device or apparatus. The judges, before making the final award of the prizes, will be entitled to require tests, and if they are not satisfied with any proposed device, they will be at liberty to reopen the competition or award a part only of the prizes.—Johannesburg, October 10th.

† MINERS' PHTHISIS.—Investigation has proved that nothing is so disastrous to the workers in metalliferous mines as the dust which arises from rock-drilling and the subsequent blasting operations. The air is made dense with sharp particles of stone when the masses of ore are shattered into fragments by the explosives, and it is the breathing of this dust which causes what is generally known as "miners' phthisis." How serious are the consequences of breathing air surcharged with minute spikes of rock may be gathered from the fact that the average life of a rock-drill worker in England is eight years, and in South Africa only four years. The period which in South Africa suffices to cause death is terribly short. That is attributable mainly to two causes. In the first place, the inspection of the South African mines is not nearly so strict as it is in England, and, what is more germane to the point, the rock-drillers in South Africa work on contract, and their eagerness to earn perhaps £60 or £70 a month deters them from waiting until the dust has settled to even a slight extent. They go into the ruinous air, and resume operations immediately after a blast has taken place. The disease from which rock-drill workers suffer is very like that which causes the early death of file-makers, whose lungs become loaded with particles of steel; and that which shortens the existence of men in the pottery-districts, who are employed constantly in breaking up flints.

Cornwall, will greatly ameliorate the conditions, the author is of opinion that no cure of the evil will result unless the drills are so arranged that they cannot be worked without water. Spraying was tried many years ago, but it is liable to be forgotten or neglected; whereas if an hydraulic drill be employed the water cannot be forgotten.

Samples of the drill-head and of the various rocks encountered in the Simplon tunnel were placed upon the table.

Mr. Francis Fox said that all masks, respirators, and water-spraying used for the purpose of diminishing the death-rate were bound to fail. Such so-called remedies had been tried, and as soon as the ganger's back was turned, off came the mask. A strong, healthy man exerting all his power and breathing a heated atmosphere could not reasonably be expected to wear a mask. Over 22 per cent. of the miners of the Rand, and he believed in Cornwall and other parts of England as well, were suffering from phthisis; that is, one in every five were doomed to die, probably within the next four or five years, and the remaining four-fifths, what of them? It was only a question of time for them to be enrolled in the same class of doomed consumptives. As mining and tunnelling engineers, the members should do their utmost to combat this terrible scourge. He (Mr. Fox) had spent many years of his life in mining and tunnelling-work, and he must say that he had never come across such a place as the Simplon works—where the conditions were so good for the workmen, and where foul air was unknown, although the temperatures of the rock and spring were so high.

Mr. J. A. Longden (Stanton-by-Dale) said that some years ago he had seen the Greathead shield in operation,* at the Blackwall tunnel, and it had been of great assistance in making various tubes for railways, etc. He had used Ingersoll rock-drills 30 years ago, but the Brandt drill seemed very much superior to them. With regard to the question of phthisis, he thought that Mr. Fox had not been quite correctly informed as to the general practice in this country. Statistics shewed that the occupation of a collier was distinctly healthy; it stood sixth or seventh on

* *Trans. Inst. M.E.*, 1895, vol. ix., page 452.

the list; and so far as phthisis was concerned, it was almost unknown. As regarded Cornwall, he had been informed that the greatest drawback to mining was the use of dynamite, as the fumes produced severe headaches in the workmen. The Cornish miner suffered more from want of ventilation than from phthisis.

Mr. G. E. Coke (Nottingham) said he had just returned from Johannesburg, and supported Mr. Longden's remarks. He found that pneumonia was very prevalent amongst the population generally. He thought that the dump-heaps of fine sand from the cyanide-batteries, insufficient ventilation of the mines, and a somewhat trying climate were largely responsible for the high mortality from lung-complaints.

Mr. C. C. Leach (Seghill, Northumberland) said that they must bear in mind that Mr. Fox's remarks with respect to the health of the workmen at the Simplon works applied to the very best selected labour that could be procured, whilst at collieries they employed any one that looked suitable without medical examination.

Mr. John Morison (Cramlington Collieries) said that he had come across rocks that no rotating drills would touch, and asked whether the Brandt drills would cut such hard rock which was harder than that found in the Simplon tunnel. He (Mr. Morison) did not think that it was fair to condemn all percussive drills, and to state that they caused phthisis. If used with proper care they were quite as harmless as the Brandt drill, so far as phthisis was concerned. He sympathized with Mr. Fox in his remarks, as no doubt a large part of the death-rate was caused by the small particles of stone becoming embedded in the lungs of the workmen; but if it was only a question of moistening the dust, then there was nothing in the construction of the percussive drill that would prevent this from being done.

Mr. Isaac Hodges (Whitwood Collieries) said that it had not been definitely proved that the particles of dust resulting from the use of percussive drills were the real cause of the high death-rate. He thought that the presence of dust at the surface at Johannesburg was responsible for much disease. What was required was better ventilation, and if the fumes of the explosives

were taken away from the workmen they would enjoy better health. The high rate of wages quoted by Mr. Fox in his paper must not be taken as exceptional, as he remembered the days (15 years ago) when Rand miners received £50 per month. With regard to the well-being of the miners—baths, refreshments, warming of their clothes, etc.—he (Mr. Hodges) thought that before Mr. Fox passed strictures upon colliery-managers it should be remembered that they had to deal with men connected with powerful unions, who extorted everything they could from the owners and gave nothing in return.

Mr. W. H. Trewartha James (London) said that he was somewhat surprised at the paper which had been placed before them—surprised at the powerful advocacy of the use of the Brandt drill, and surprised at the view as to the prevalence and cause of phthisis among miners, as it was not in accord with his observations during 24 years' experience in percussive drilling. With regard to the Brandt drill, as a rapid and efficient boring tool, the facts placed before them would have the serious consideration which they deserved. With regard to phthisis being produced entirely by dust from dry drilling, it must be borne in mind that, in metalliferous mines, sometimes 75 per cent. of the holes were wet holes, so that the amount of dust which Mr. Fox had postulated was not produced. He (Mr. James) considered that the question of ventilation had more to do with the disease than the amount of dust. The matter was possibly one for medical men rather than for mine managers. With regard to introducing the Brandt drill into metalliferous mines, they would have to look at the question from every point of view, and he foresaw many difficulties to be overcome. It had to be demonstrated that a hole of suitable size could be cheaply and rapidly bored in rocks of great degrees of hardness, that the installation of the plant compared favourably as to prime-cost, wear-and-tear, etc., and that the arrangement was sufficiently flexible for the exigencies of metalliferous mining. At the Quebrada copper-mines, Venezuela, where the dust from decomposing pyrites was worse than anything he had ever experienced, from 20 to 40 Cornish miners and nearly 1,000 Italians, Venezuelans, West Indians, etc., were employed. During six years, only 1 Cornish miner died, and his death certainly was not due to phthisis,

and he could not remember a single case of phthisis among the others. He was led, therefore, to believe that other conditions, besides dust, must combine to cause this disease, and that dust alone did not necessarily cause it.

Mr. Armand Halleux (Brussels) wrote that the paper by Mr. Francis Fox seemed to be very imperfectly supported by documentary quotations. At the Simplon tunnel, the Brandt drill was only used to drive the basal level of the tunnel, the former having an area of 5 square metres; and the remainder of the section of the tunnel was broken without the employment of the machine. He considered that, in examining the question of the rapidity of tunnelling, there were other elements to be considered besides the drilling-machine; the arrangements adopted for the working-face, for ventilation, and, above all, for transport, played a very important part in the rapidity of working. At the St. Gothard tunnel, for example, a heading at the top was employed, whereas at the Mont Cenis and Simplon tunnels the preference had been given to a heading at the base of the section. Moreover, at the Simplon tunnel, about 70 per cent. of the total time was employed in charging the shot-holes and in removing the débris. It would thus be recognized that this time was far from a negligible quantity.

Concerning the question of hygiene, which was touched upon in the paper, it must be observed that at the Simplon tunnel the use of the Brandt drill bringing water into the working-face had produced a humidity of the air which was injurious to the health of the work-people, especially having regard to the high temperature. Mr. Fox seemed to favour the employment of the Brandt drill in mines so as to avoid the production of rock-dust, but it should be noted that in Belgium, when air-driven rock-drills were employed, water was frequently projected into the bore-holes so as to avoid the production of dust. Moreover, for mine-drifts, with small sections, the Brandt drill presented the following objections:—(1) Difficulty of arranging the bore-holes suitably to a rational system of working, on account of the distance between the axis of rotation of the drill-carrier and the working-face; (2) the employment of bore-holes of large diameter, necessitating the employment of heavy blasting-charges, and consequent dislocation of the strata: (3) the dis-

location of the strata was favoured by the presence of water; and (4) the employment of special pipes under heavy pressures.

Dr. T. OLIVER (Newcastle-upon-Tyne) wrote that like Mr. Fox, but without his professional knowledge of tunnels and the best methods of making them, he considered the operations which were at present being carried on at the Simplon tunnel as a triumph of engineering skill and an instance of what hygiene could accomplish for the health and comfort of miners.* It went without saying that the more rapidly the tunnelling of a mountain could be effected the greater was the saving of capital and to that he thought might be added, where ordinary precautions were taken, the saving of human life. Although nearly twice the length of the Mont Cenis tunnel that of the Simplon would be completed, if all went well, in half the time; and while it was longer by 3 miles than the St. Gothard, the Simplon tunnel would be finished in 5 instead of 10 years. It was true that the temperature in the interior of the mountain had reached a higher point than was expected; but the contractors had, on the whole, pretty successfully coped with this, for by means of free ventilation and the unstinted use of water the harmful effects of high temperatures upon the workmen had been materially reduced. Such hard work as mining carried on in a confined space and where the temperature ranged from 97° to 131° Fahr. could not be other than exhausting to the men, and yet the miners on emerging from the tunnel after their day's work were buoyant and seemed to be happy and did not exhibit signs of undue fatigue.

Having visited the Simplon tunnel and seen for himself the workmen's houses and the commodious buildings at either portal of the tunnel in which the men on leaving work exchange their wet for dry clothes, have a warm bath and if necessary warm food, he could endorse all that Mr. Fox had said of the special care which the contractors have for the health of their workpeople and of the desirability of some of our large engineering firms and mining companies making similar provision for their employées. At the Simplon tunnel, there had not been one case of that particular form of pulmonary consumption due to dust

* "A Visit to the Simplon Tunnel: The Works and Workmen." By Dr. Thomas Oliver, *Trans. Inst. M.E.*, 1902, vol. xxiii., page 200.

getting on the lung. A few of the miners had died from the effects of neglected colds and from incompletely recovered pneumonia, in whom the fatal termination was accelerated by excessive indulgence in alcohol; but none of the men had died from miners' phthisis in the ordinary acceptation of the term. This circumstance was very largely, if not entirely, due to the fact that the Brandt drill worked under hydraulic pressure so that part of the water which was used was allowed to escape and thus allayed the dust. It was the hard, angular and stony particles of the rock which when inhaled in the form of fine dust induced those structural alterations in the lungs that ended in phthisis. That the lung-disease was not caused by the soft particles of carbon or soot was proved by the fact that where workmen had been accidentally killed and Dr. Volante, of Iselle, had made, as he was required by law, a post-mortem examination, he had invariably found that the miners' lungs were perfectly black and yet the anthracosis was consistent with good health, perfect fitness for work, and freedom from symptoms. The pigmentation of the lung revealed under these circumstances was the result of the inhalation of the smoke from the miners' lamps and from the engines in the tunnel. They might contrast this freedom from pulmonary phthisis in the miners at the Simplon tunnel with the great mortality from the disease in the Transvaal miners, who follow the dry method of rock-drilling. It was appalling to find that such large numbers of young South African miners have died from pulmonary phthisis. The methods of mining adopted at the Simplon tunnel showed how the malady might be obviated.

So far, therefore, as the medical aspects of tunnelling are concerned the main points are good ventilation and means to prevent and to allay dust: proper water-supply; good housing for the workmen; suitable food; and medical inspection of the miners before being allowed to work. It is by attention to such details as these that not only must the freedom at the Simplon from pulmonary phthisis be attributed; but also the absence of that terrible scourge of the miner, the *ankylostomum duodenale*, or the intestinal parasite that sucks the blood of its host and induces what is popularly known as "miners' anæmia."

Mr. W. Price Abell (Duffield) said that his friend Mr. Lean so appreciated the bad effects of bad gases (resulting from blast-

ing) travelling along galleries, that in the Sheffield water-works-tunnel, which would eventually be 5 miles long, he had decided to exhaust the air from the working-face, thus removing the injurious gases, also the dust from the percussion-drills by laying a pipe, 10 inches in diameter, along the tunnel, and exhausting the pipe at the electric station outside it. It would be interesting if Mr. Fox could give data as to the water-gauge and the system of ventilation adopted at the Simplon tunnel.

Mr. F. C. SWALLOW (Nuneaton) wrote that at present he was engaged in the work of tunnelling a distance of about 2,500 feet at one of his collieries through Silurian strata with occasional beds of granite. Air-driven rock-drills were used, and he believed that he was obtaining as cheap and rapid driving as had yet been obtained in this country.

Mr. FRANCIS FOX, replying to the discussion, said that he had not given the statement as to miners' phthisis upon his own authority; but it was the result of careful medical examination. There could be no doubt that the fumes from explosives were exceptionally bad, and if the ventilation was excessively bad nothing more was required to induce all kinds of disease. He himself was regarded as an apostle of fresh air in mines, buildings, churches, chapels, etc. He asked the members whether they had ever examined the dust that came from dry drilling in advance-headings? If they examined it under a microscope, they would readily understand its effects upon the lungs. It was a mass of knife edges, and when the drills were battering away at the rock the air was as thick as a London fog. Dust in every form was objectionable, but in advance-headings, and with bad ventilation, the results were simply disastrous. Engineers would be doing wrong if they went away that day with the opinion that it was not the dust that was the cause of phthisis among miners engaged in dry drilling. With regard to coal and metalliferous mines, he had specimens of miner's lungs choked with dust from coal-mining, and he did not consider that healthy, although they were not suffering in this respect to the same extent as the miners on the Rand and in other mines. He spoke there that day on behalf of the health and welfare of the miners. A great deal had been done, no doubt, by colliery-owners and colliery-managers for the benefit

of their workmen; but if they wanted to have a really good object-lesson, let them visit Switzerland and see what had been done at the Simplon tunnel-works.

The PRESIDENT (Mr. J. C. Cadman) moved a vote of thanks to Mr. Francis Fox for his interesting paper directing attention to miners' phthisis.

Mr. C. C. LEACH seconded the resolution, which was cordially approved.

DISCUSSION OF MR. W. BLAKEMORE'S PAPER ON "THE FERNIE EXPLOSION."*

Mr. W. BLAKEMORE (Montreal) wrote that he had to thank the members for the interest that they had taken in his paper, and especially for the vote of thanks that they had accorded to him. He felt particularly gratified that his paper had aroused such general interest, and that the discussion had elicited a fund of information and opinion far more valuable than anything contained in his paper. He had no doubt that the members realized that the subject was handled in a manner intended to evoke discussion, which accounted for his having withheld his own definite opinion on some important points, but he felt it was of greater importance that influential members should be induced to make statements with regard to some of the vital features affecting explosions rather than that he should give his own views.

It was not unknown to him (Mr. Blakemore) that the Camerton and Timsbury explosions had been attributed to coal-dust, and he was so convinced that the Fernie explosion was due to the same cause that he had no hesitation in giving that opinion, so soon as the general conditions had been explained to him. On the other hand, the Government experts on the day of their arrival telegraphed a statement to the Government, to the effect that it was not a coal-dust but a gas-explosion. He was glad therefore that, from the data submitted, the members who had taken part in the discussion arrived at the same conclusion as the writer and the coroner's jury who investigated the matter on the spot.

The suggestion of Mr. W. N. Atkinson that, "If these men had remained in No. 1 district, and had done their best to prevent

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 450.

the after-damp from invading it, it is possible (if not probable) that they might have lived until the road out was sufficiently ventilated for them to be able to escape by it,"* was interesting; but he thought that a consideration of the conditions prevailing would preclude such a possibility, because, as pointed out in his paper, both air-crossings were completely destroyed, and from the mouth of the main entry to the mine (that is No. 2) beyond the branch road into No. 1 district (that is beyond the point E), the entry had fallen in and the work of advance was slow, so that it was several days before the point E was reached, and by that time there was no doubt that No. 1 district was full of after-damp. He considered that the range of the explosion practically extended from the Beaver level to the extreme western limit of No. 2 district, and the only reason that the men from No. 1 district were able to escape (even as far as the point E) was that the force of the explosion along the far end of the main level and main return was less than in the faces and near the main deep and Beaver deep. Consequently the air-stoppings were less affected, and there was not that freedom of travel for the fire-damp as in the larger district where every barrier was practically removed. He thought there could be no doubt that very shortly after the men left the working-rooms in No. 1 district, the after-damp reached that point. Mr. W. N. Atkinson was correct in supposing that there were other connections between Nos. 2 and 3 mines than those shown on the plan; but, as he had explained, the sketch that he was able to obtain was not an actual survey, and this removed the difficulty of explaining why the men were able to escape up No. 3 deep.

He (Mr. Blakemore) considered that one of the most important points raised in the discussion and the one upon which he was most anxious to obtain light, was that mentioned by Mr. Donald M. D. Stuart as to the phenomena of propagation. He thought that this was a subject upon which mining engineers generally were most anxious to obtain information, and he was not sure that it did not hold the secret of successfully coping with explosive conditions in a mine. He thought that the Fernie explosion was a typical case for the study of such conditions, and he only regretted that observations were not made by competent experts in a thoroughly scientific manner imme-

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 462,

diately after the explosion, in order, if possible, to obtain sufficient data to enable a definite theory to be established. On this point, however, he might remark that the report of the Government experts, together with a *verbatim* report of all evidence taken at the inquest and also by the Government Commission which had since dealt with the case, would shortly be available. It was possible that from this evidence members who were deeply interested in the subject might gather more information than he had been able to include in his paper.

Mr. J. B. Atkinson had apparently overlooked a paragraph in the paper when he said that it was not stated in which direction the force had passed, where the main air-crossings and nearly all the air-stoppings alongside the main deep and main level were blown out.* He (Mr. Blakemore) had written in his paper as follows:—"Thus, taking the main deep (Fig. 1, Plate XII.), nearly all the air-stoppings on the eastern side of the main deep were blown westward towards the deep, while several of the air-stoppings on the western side of the main deep were blown eastward."† This would indicate that the force of the blast had passed from both east and west towards the centre and the main deep. Surely, this was to be accounted for by the fact that this main deep afforded the largest area and the most direct and easy escapement for the blast. Mr. J. B. Atkinson's conclusion that "it appears . . . . impossible to suppose that the atmosphere of any considerable area of workings could become explosive owing to the presence of fire-damp, without the miners having observed gas firing in their lamps,"‡ was quite correct and in exact accordance with the evidence. As a matter of fact, the most lengthy investigation led to the positive conclusion that no gas was known to exist in the mine, either immediately before or after the explosion, except that in the MacDonald level at the point D, and this rendered certain the conclusion that the explosive-agent was coal-dust and not fire-damp. He (Mr. Blakemore) must take issue with one point raised by Mr. J. B. Atkinson, where he considered that the writer was in error as to the freest and purest coal-dust existing in working-places. It must be admitted that Mr. J. B. Atkinson was right in laying down a general rule, but surely even this feature might be dependent

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 465.

† *Ibid*, page 458. ‡ *Ibid.*, page 466.

upon circumstances. When Mr. J. B. Atkinson said that the "greatest force is always developed upon haulage-roads, where such fine dust exists,"* he was generalizing: would he adhere to the same opinion in the case of a mine where the coal was the most friable known, where it was of the character so well described by Mr. W. D. L. Hardie, and, therefore, as Mr. James Ashworth pointed out, in consequence of the presence of some of the heavy "hydro-carbons distilled in quantities large enough to cause an explosion of any magnitude?"† And would not Mr. J. B. Atkinson's view be further modified by a consideration of this fact, namely, that in a number of rooms in No. 2 district shown upon the plan the coal was undercut by machines of the percussion-type, which produced not only an enormously greater quantity of dust than in the case of hand-picks but dust of the finest grade? Was there any doubt in Mr. J. B. Atkinson's mind that, in the absence of fire-damp, the severity of the local explosions was entirely due to the greater accumulation of clean coal-dust of this character? And would he not admit that, apart from the fineness of the dust, the fact that dust upon the haulage-roads would be partly coal-dust and partly dust of shale was opposed to his idea that the greatest force must necessarily be exerted there? He (Mr. Blakemore) thought that the remark of Mr. H. Hall was very suggestive, as to the renewal of the violence of an explosion again and again on meeting with fresh supplies of air from the several air-ways; and it was a fair matter for discussion whether this, or an increased quantity of coal-dust at any given point, was more directly answerable for the local explosions. He noticed that Mr. H. Hall arrived at the same conclusion as he had stated above, in reply to Mr. W. N. Atkinson, as to how it was possible for the men of No. 1 district to get as far as the point E. But he wished that either Dr. Haldane or some other eminent authority could have satisfactorily answered Mr. Hall's second query as to carbon-monoxide poisoning; while Mr. J. Ashworth's, as to the possible action of electricity upon the explosion was worth consideration. He might state that, in the present instance, he did not think that the latter was possible, especially as there were no electric wires within a long distance of either the point C or the point D, or indeed at any place where, judging from the evidence of the conditions prevailing, the explosion could possibly have originated.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 467. † *Ibid.*, page 470.

He (Mr. Blakemore) could answer Mr. Ashworth's question as to the kind of stoppings which were placed between the old gob and the working-faces and on either side of the main haulage-road. These stoppings were all constructed of rock and earth, and were said to vary from 6 feet to 12 feet in thickness, and to have been well built into the roof and sides. These stoppings were blown out. In thirty years' experience, he had never known stoppings of this character to be moved by an explosion.

The concluding remarks of Mr. H. W. G. Halbaum were of great interest, and he quite agreed with him that it was very desirable that the nomenclature of explosions should be overhauled and revised. He thought also that Mr. Halbaum had quite satisfactorily explained the passage of the blast through areas which were comparatively wet. He had arrived at the same conclusion at the investigation, namely, that this was mainly owing to the enormous quantity of coal-dust found throughout the mine. As to the abolition of blasting from dry and dusty mines, he noted that Mr. Halbaum and himself had arrived at the same conclusion, though from different premises. Mr. Halbaum said that blasting could be made perfectly safe if certain conditions were observed. In reply, he (Mr. Blakemore) would ask whether it was possible to guarantee the observance of such conditions as would render blasting absolutely safe. In other words, was it easier to abolish the blasting, or to abolish the dry and dusty mine? The former presented no difficulty, the latter many, and the sacrifice of human life was the price being paid for the non-observance of recognized and specified precautions. The very fact that Mr. Halbaum was able to state that "he had yet to hear of the explosion that had occurred where all of the precautions which he had mentioned were faithfully observed,"* was the strongest argument in favour of his (Mr. Blakemore's) contention, since explosions continued to occur and must do so, if Mr. Halbaum's conclusion be justifiable, that they were the result of neglecting to observe precautions which would prevent them. He claimed, therefore, that the other step should be taken, namely, that of prohibiting the introduction of dangerous implements.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 476.

Mr. Alexander Faulds (Vancouver Island) wrote that in compliance with request of the Minister of Mines for the Province of British Columbia, he proceeded to Fernie to ascertain the cause (if possible) of the explosion which occurred on Thursday, May 22nd, 1902, about 7·30 p.m. in the No. 2 mine, Coal Creek, owned and worked by the Crow's Nest Pass Coal Company, Limited. The examination occupied twelve days, inspecting all the accessible working-places, haulage-ways, return-airways, and waste-workings minutely and carefully; and making a report thereon, with drawings, entailed as many days more.*

Mr. Blakemore stated that "a cloud of dust [was] blown from the mouth of No. 2 mine and through the roof of the fan-house."† In addition to these two exits, the explosion expended itself from the mouth of the No. 3 mine, the original tunnel, and the first drift to the north off the slope of the No. 3 mine, altogether five exits.

One of the survivors, the trip-rider, W. R. Henderson, said that "the blast came up the slope, meeting the trip of eight empty cars (the last car of which I was upon), at or near the seventh cross-cut to the right of the slope, derailing the trip into three portions. I felt the blast distinctly and was stunned, but saw no flame, and got out to the surface as best I could." This description of the sensation experienced is interesting, as bearing upon the physical change which affects the unfortunate victims of an explosion. This person experienced a drumming pain in the ears and a stoppage of the nasal passages, indicating an outward pressure of the containing membranes and tympanum due to a partial vacuum of the surrounding altered atmosphere. He (Mr. Faulds) had experienced similar sensations in two explosions, in which he was involved on Vancouver Island. These sensations would suggest that, under severe conditions, membranous rupture occurs and instantaneous unconsciousness precedes death.

"There must have been local explosions. . . . . This is shown by the fact that at G, in No. 1 room of the MacDonald level, at H, near the face of the MacDonald level, and at I, in No. 1 machine-room, the bodies of men were found terribly mutilated."‡ At G, before entering the old workings, at D, where the explosion

* *Reports on the Fernie Coal-mines Explosion*, 1902, page 43.

† *Trans. Inst. M.E.*, 1902, vol. xxiv., page 450. ‡ *Ibid.*, page 452.

originated, and at I, which was a confined area, with only a small connection (2 feet by 2 feet or 4 square feet) to the other workings, there was excessive pressure, and the force was intensified by the dust, through being confined to some extent as described.

"This leads to the consideration of the probable locality and cause of the explosion, and upon this point it is only fair to state that two totally distinct theories were put forward at the inquest . . . . The theory brought forward by the workmen's committee . . . . attributed its origin to the firing of a shot in a cross-cut near the face of No. 1 machine-room at C."* In the cross-cut to the left of this room, 18 feet 8 inches back from the face of room, the coal was mined or holed 41 inches under and jibbed or spragged, being the second cut or holing, and being very friable it did not require to be blasted. In the face, some coal was down, the roof-rock having fallen for 45 inches inside the cross-cut and broken down the overhanging coal adhering to the roof. There was no evidence of recent or any blasting, in fact, there was clear evidence that the direction of the force in No. 1 machine-room was up the room towards the cross-cut and not away from it, as would have been the case had a shot been fired originating the explosion there. The positions of the men at the bottom of the room, having been blown in towards the room, of the shot-lighter, of the lighter material blown off the car carrying the machine, of the props and débris found against the side, and the confirmatory evidence of force observed outside the room, all proved that the blast was up the room from, and not towards, the MacDonald level by the airway marked J. All the evidences of the force and of the blast were towards and not from C; and as there was no evidence of subsidence or cavities in the roof in this solid working there could not possibly be any local explosions from gas, but only an intensifying of the original explosion by the impalpable dust in this working-place.†

"Matches were found in the pockets of some of the miners, as well as pipes and tobacco, but none were found in the pockets of the men recovered from the MacDonald level." "No prospective headings were in operation, which could un-

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 453.

† *Ibid.*, Plate XII., page 460; and *Reports on the Fernie Coal-mines Explosion*, 1902, pages 13 and 69.

expectedly tap a large feeder . . . . there was no accumulation of gas in the old workings . . . . throughout the whole of the mine there was a considerable accumulation of coal-dust. In the main roads, ... to a depth of 18 or 20 inches. In the old workings . . . . no dust whatever had been removed since the workings were shut off, and that there was a considerable quantity there. . . . . No regular staff of men [was] employed for the purpose, and no rule for constant removal."* Twelve matches and half a package of tobacco (2 ounces) were found on one of the miners (Dugald Milroy), who worked with James Muir in the MacDonald level, which with the Alder or Beaver level, were the prospecting places in operation, liberating blowers or feeders of gas very frequently from roof, floor and sides. There may have been inaccessible accumulations of gas in the roof of the old workings. The accumulation of dust in the main roads did not amount to near 18 or 20 inches, and the dust on the motor-roads was very much mixed with sand. The dust in the old workings was also much mixed with sand from the fallen roof, immediately above the coal, which was a faky or shaly sandstone. The dust was frequently removed from the main roads in the night-shift.

"The only problem in the whole case is as to how it [the explosion] was started."† The problem of origin does not seem so difficult, because the probability is that it was started either from a miner's (James Muir's) lamp in some way, or more probably from the lamp of his partner (Dugald Milroy), who had twelve matches and half a package of tobacco (2 ounces) in his possession, by his either striking a match or drawing the flame of his safety-lamp through the gauze, for the purpose of lighting his pipe.

"Is it within the knowledge of any of the members that under such conditions an explosion has been produced without the presence of gas?"‡ This might be answered by Mr. Joseph Dickinson, late H.M. inspector of mines, who claimed that sudden compression of air in the presence of coal-dust might cause ignition to the extent of an explosion. It is certainly answered in the affirmative by Mr. W. N. Atkinson, H.M. inspector of mines, and is illustrated by "the occurrence of exten-

* *Trans. Inst. M.E.*, 1902, vol. xxiv., pages 454 and 455.

† *Ibid.*, page 455.

‡ *Ibid.*, page 455.

sive explosions in old collieries, like Camerton and Timsbury, in Somerset, where fire-damp had never been found, either before or after the explosions."* "Coal-dust has been frequently set on fire by a blast, and great difficulty has been experienced in extinguishing it. Is it possible that this ignition may have gone to the point of explosion?"† Evidence was given that these fires were easily extinguished with a few buckets of water, and that they never reached the explosive point, but simply burnt for a short time.

"The lamp in use must be undoubtedly classed among the defective safetys. It is a simple bonnetted Clanny lamp, ... in contact with any feeder of gas would immediately become an instrument of danger and of possible ignition."‡ This class of lamp is of the same type as those used in the mines on Vancouver Island, and the same pattern is used in Great Britain and only passes flame at a velocity of about 80 feet per second. It cannot be exactly stated that these Clanny lamps are an immediate or direct instrument of danger; and they cannot be called defective because of their passing a flame at a lower velocity than the Wolf lamp, which passes flame at a velocity of 100 feet per second. Some of the best-known failures of bonnetted Clanny lamps occurred at Whitfield colliery in 1889, Allerton Main colliery in 1894, Shakerley colliery in 1895, Wishaw colliery in 1895, Universal colliery in 1901, and Abertysswg (Tredegar) colliery in 1902. The only source of flame in these cases was a safety-lamp of the bonnetted Clanny type; and on examination and experimental testing (coal-dust not forming a factor) in no case was the lamp found to be deficient.§

"The theory that the small feeder of gas, referred to, originated the explosion is not, in the writer's [Mr. Blakemore's] opinion, a very strong one, for the following reasons:—(1) The quantity of gas given off was so small, that only in the case of almost incredible carelessness could it have accumulated in sufficient quantity to have caused an explosion. (2) It was known to exist a long time before the occurrence of the explosion."‖ "Whenever the cars were run into the Beaver [it

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 461.

† *Ibid.*, page 456.

‡ *Ibid.*, page 456.

§ *Ibid.*, 1902, vol. xxv., page 71.

‖ *Ibid.*, 1902, vol. xxiv., page 456.

should be the MacDonald] level the door, EG, was open and possibly . . . . . left open until the return of the driver."* The quantity of gas given off by the gas-feeders in the MacDonald level must have been sufficient to foul the air-current at that point to explosion-point, as the feeder was audible, at a distance of about 20 feet, 15 days after the explosion. And because this level was in the return-airway from the main entry, and as H.M. inspector of mines frequently detected a blue cap on his safety-lamp while testing the return-airways to the extent of 3 per cent. of fire-damp, it is possible and very probable that this level contained a higher percentage of fire-damp at the time when the explosion occurred.

The feeder or blower of gas in the roof could not have existed long before the explosion, because there was clear evidence that James Muir had been in the act of mining or holing, and while doing so that he had exposed this blower in the roof. It was found 18 inches from the coal-face and 5 feet from the lower coal-rib. Muir had mined an area, about 5 feet long, 23 inches deep and 34 inches thick, in the top coal; and, when working, his lamp probably was placed adjacent to the blower and may have got damaged, or the flame may have passed in some way from the lamp to the explosive mixture. A more probable and likely cause was that Dugald Milroy (the partner of Muir), whose head was seriously injured, may have been in the act of smoking. To undermine this area, and to expose the blower would occupy Muir from the beginning of his shift at 3 p.m., until about 7·30 p.m., at which time the explosion occurred.

As to the trap-door, at EG, being left open, there was only one loaded car near the face of the MacDonald level, and as the driver and the mule were found about 650 feet away from this door on the same level in a siding near the Beaver slope, with other cars, this is certain evidence that the door was closed and had not been left open for traffic in the level at that time. A driver seldom, if ever, leaves such a door open, unless he is working the traffic of that particular part.

"Conflicting direction of forces . . . . nearly all the air-stoppings on the eastern side of the main deep were blown westward towards the deep, while several of the air-stoppings on

* *Trans. Inst. M. E.*, 1902, vol. xxiv., page 457.

the western side of the main deep were blown eastward." "Coal-dust . . . . found upon the posts" . . . . "Conclusive evidence as to direction of force may be extremely important in fixing the location whence the explosion started originally."*

Coke and coal-dust were found in the following locations:—

In No. 1 district the dust found on the motor-road consisted of sand from the motor, dust from the roof and sides, as well as from the coal in the cars; and the dust on the other roads was similar, except for the absence of motor-sand.

In No. 2 district of the air-hoist level, there was coking on a set of timbers which were not blown out in this level, between Nos. 7 and 8 rooms. There was coal-dust, on a post about 60 feet down the return-airway, at the face of the air-hoist level. There was coking on two sets of timber between Nos. 14 and 15 rooms, in the air-hoist level.

In the machine-section of No. 2 district, hard coke was found on the top of a prop beside a cap or lid, 39 feet back from the face and 5½ feet from the right hand coal-rib of No. 4 room. The machine-entry, fourth cross-cut, was coked back from the face for 60 feet. Two pillars to the left of the Sharp slant were coked slightly on several posts.

In No. 3 district of the Beaver slope, coke was found on a post east of the entrance to the Galloway level; and there was a prop with coke and coal-dust thereon near the entrance to the Hunter level. In the MacDonald level, coking was very pronounced on the roof, sides, props and bratticing of No. 7 room, the heat having been evidently greatest here.

In No. 3 mine, a post was charred in the Hunter level in the old workings, a little to the north of No. 14 room off the first south level; there was coke on a post at the northern corner of and entrance to No. 15 room, and coke on a post in a slant off the first south level inside of No. 10 room. There was no other evidence of coking in this section, but dust showed the direction of the blast. This section was wet. The remaining area in No. 3 mine was wet, and there was no evidence except that the explosive blast had expended itself through the main slope and old workings to the surface.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., pages 458 and 459.

The dry and dusty portions of Nos. 2 and 3 mines are chiefly found at the working-faces and for about 60 feet back therefrom. The machine-section was dusty at the end of the main entry in No. 2 district, and more or less dust was found in the haulage-roads. Nos. 2 and 3 mines are not dry and dusty throughout, No. 1 district is moist, No. 2 district is damp, No. 3 district is damp, Beaver slope is wet, and the north and south sides of mine No. 3 are rather wet.

"Wet areas had no effect upon the spread of the explosion;"* "none of them [the permitted explosives] . . . . are sufficiently safe to meet the reasonable requirements of modern mining."† The wet areas chiefly in the floors being small and of insufficient linear extent (about 50 feet), were in consequence ineffectual in intercepting the explosion. The permitted explosives are practically flameless, especially those of the ammonium-nitrate class, which as a rule produce very little flame and might reasonably be said to be sufficiently safe for modern mining. The usual grade of black blasting-powder was in general use where the workings were not wet; and, where the working-places were wet, dynamite or giant-powder was used.

There had been no derangement of the ventilating current, the airways were found of ample area after the explosion and must have been so before the explosion. No falls of roof had occurred. The barometer had been steady at 26·20 inches for two days prior to the explosion; the maximum for May being 26·46 inches on the 7th, and the minimum 25·75 inches on the 18th, with 2 feet of snow. A sudden increase of gas from a feeder or blower, which occurred, will be considered hereafter.

Coal-dust was more or less prevalent in the air of the ordinary galleries of the mine, and more abundant at the working-faces, still it could not be termed a dry and dusty mine throughout, and there was no evidence of any blown-out or windy shots or blasting at the working-faces, or elsewhere, immediately preceding the explosion.

There had been no pressure due to heavy blasting or any concussion of the air, caused by the closing of doors, which is only a momentary pressure. In the latter case, the explosive condition of the air would necessarily have to be close to the

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 460.

† *Ibid.*, page 461.

limit in order that such a slight occurrence could precipitate an explosion.

A rapid succession of shots or volley-firing may happen when two, three or more shots are fired in close proximity producing, through incomplete combustion, carbon monoxide, and if the workings are dry and dusty, an explosion may often be precipitated by such an occurrence. The only rapid successions of shots or volley-firing in practice, occurred in a rock-tunnel in No. 1 district, and these were fired in the night-shift, when there were few men in the mine. As the coal is easily got, and all shots are located and fired by the shot-lighter, and only one shot ignited at a time in each place (excepting in the rock-tunnel), no likely danger could arise from that practice.

As to the accidental discharge of an explosive in a "dirty" atmosphere, the only evidence in this respect shewed that powder-cans or canisters had been exploded in the path of the explosive blasts, but not before the explosion.

The ventilation (by a Capell fan, 16 feet in diameter and 8 feet wide, and capable of producing 240,000 cubic feet of air per minute), was thoroughly adequate in quantity, 80,000 cubic feet passing per minute in No. 2 mine and 30,360 cubic feet per minute passing in No. 3 mine: a total quantity of 110,360 cubic feet per minute passing for 150 men, 21 horses, and the old workings, with a water-gauge of 0·87 inch. The ventilation was maintained to the working-faces, in compliance with the Coal-mines Regulation Act. Too much ventilation in a dry and dusty mine is also a source of danger. The velocity of the air going into No. 2 mine was 1,600 feet per minute, or about 18 miles an hour. This was a high velocity, and would be considerably safer if reduced by one half to about 9 miles an hour, by forming more intake-airways.

The evidence at the inquest proved that, before firing shots and after making an inspection for gas, the mining or holing, the floor and the sides (but not the roof) were watered for a distance from the face of about 12 feet (with plenty of water) instead of 60 feet as the law requires. Probably the best and most efficient way of dealing with the dust would be to thoroughly wet or saturate it by means of the water-spray system, with pipes laid in the main haulage-roads and airways.

The safety-lamps in general use were of the bonnetted Clanny

type, with an illuminating power of 0·20 sperm candle. At the time of the explosion, Wolf lamps were being introduced into the mines, but there was no evidence to show that the lamps in use in these two mines were responsible for the explosion. Many foreigners were employed in the mines (there were no Chinese nor Japanese, who make careful and obedient miners), men who think that if they have a safety-lamp in their hand everything is all right. Much danger may arise from this fool-hardiness, but it can be speedily overcome.

The direction and course of the blasts were traced by the evidences of coke and dust-deposits, displacement of bratticing and timber, shattering and blowing-out of doors, stoppings and air-crossings, derailing and overturning of cars, mining machines, the position of bodies, etc.

There can be no doubt as to the explosive condition of the MacDonald level, where the explosion originated; but it probably would not have gone through the whole of No. 2 mine if an effective system of watering had been adopted, or some other treatment equivalent to watering in all parts where dust was lodged, whether on the roof, floor, sides or timbers, and if the other feeders of gas had not existed.

The blasts traversed the return-airways as well as the intake-airways, doing as much, if not more, havoc in the working-places, and return-airways than in the intake-airways, and haulage-ways. On some of the haulage-ways, the havoc was moderate, excepting at air-crossings, proving that it was not a dry and dusty mine throughout.

The Beaver level was wet, and the MacDonald level was slightly damp. There was very distinct and strong evidence of force from the face of the MacDonald level outward (to the north) by the way that the cars were blown and also from the position of the bodies. There was a very striking illustration: a tamping bar (stemmer) was bent (to the north and outward) quite semicircularly around a vertical post or prop in the MacDonald level, about 10 feet beyond or outside of the northern corner of the entrance to No. 8 room.

An approximate analysis of the lives lost in the Fernie explosion would be somewhat as follows:—Of the 126 deaths, 17 per cent. were due to suffocation by choke-damp, about 63 per cent. were due to the force of the blast, and probably about 20 per cent. were due to carbon-monoxide poisoning.

Dr. J. R. M. Robertson (Sydney, New South Wales) wrote that the absence of detailed plans and explanations of all details descriptive of the exact state of the mine, especially at or near the scenes of greatest violence or the suggested spots where the explosion or explosions originated, rendered further remarks difficult.

It appeared, however, that this was a typical explosion of coal-dust or a series of local explosions following on the first in such rapid succession, that at the surface only one great blast was appreciated. He was also inclined to think that the disaster was intensified by the presence of gas, indeed the ignition of such an accumulation may have been the initial cause of the disaster. He (Dr. Robertson) was also inclined to the opinion that the disaster began at or about the point, D, on the plan.* Possibly some temporary derangement in the brattice near the last cut-through in the MacDonald heading caused an accumulation of gas at that point and, with the abundant dust which appeared to have been a feature of this mine, formed a mixture that was ignited by the flame from a shot or from a damaged lamp or possibly from a match, and with much surprise he found that the workmen were permitted to convey them into the mine. From this as a centre, local explosions were propagated into different parts of the mine in a manner not yet satisfactorily explained—possibly by percussion.

Personally, he did not see anything remarkable in the evidence of contrary forces at C and D, or at other parts of the mine. This indeed was a feature in all such calamities: evidences of conflicting forces occurred and were not always easy to explain or even to reconcile. The origin of the disaster may have been at either of these points, although he (Dr. Robertson) thought that the combination of favouring circumstances at D was most likely to initiate the first of the series of explosions at that point.

The immense quantities of pulverulent dust throughout this mine, its height above the sea, the dryness and comparative rarity of the air, and the presence of gas constituted, he (Dr. Robertson) thought, special elements of danger; the crude

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 460, Plate XII.

methods of removing the dust, the absence of systematic or efficient watering, the lax discipline that permitted matches and tobacco-pipes to be conveyed by workmen into this dry, dusty and gassy mine, while safety-lamps of doubtful security were alone used, were factors that doubtless played a part in causing or intensifying a disaster, so severe that four weeks were required for the recovery of the bodies.

The severity of the explosions and their widespread character left no doubt as to the principal agent: the hot and burning dust found at long distances from the scene of any of the explosions, and the large quantity of coked dust found everywhere bore testimony to the number and completeness of the explosions—possibly these were simultaneous—and if so the question arises:—By what force were these local explosions propagated? not, he (Dr. Robertson) presumed, by the actual transmission of flame, but apparently by percussion or some force akin to this. The propagation of such explosions into distant parts of an extensive mine was a subject fraught with interest, and one that deserved close investigation.

So far as he (Dr. Robertson) could discover, there was nothing singular in the Fernie disaster as to the immediate causes of death. In all such cases, some deaths can be traced to mutilation, from proximity to the actual force. A remarkable circumstance in such severe explosions is the large proportion of cases where death has been instantaneous, where the bodies show no marks of violence or of burning, being to all appearance uninjured, but where all the evidences exist of an absolutely instantaneous death: in the act of undercutting the coal-face, of erecting a prop, of putting on a garment, or of drinking from a flask. In such cases, death could not have been the result of breathing or inhaling the gases resulting from combustion. The victims died before these could have reached them. Had percussion played any part in such deaths?

In other cases at greater distances and removed from the actual track of the force, workmen lose their lights by the violence of the shock, sometimes their hearing, and are stupefied and terror stricken by the knowledge of a calamity which they feel has occurred, they unreasoningly rush in flocks to the intake-airways, there to be overcome by the gases resulting from the explosion or from imperfect combustion of dust carried by

the ventilating currents. As a rule, workmen become panic-stricken: few there be who retain their composure, or who act with deliberation, or who can intelligently plan or effect their escape. At Fernie colliery, this was exemplified by the men who attempted to escape out of No. 1 district. This was indeed one of the unfortunate incidents common to such disasters. On the other hand, it was to be regretted that the absence of details in the description, which in other respects was lucidity itself, or on the plan submitted, made it rather difficult to understand how a body of men could escape from No. 3 mine. It seemed incredible.

After a recent colliery-disaster in New South Wales, some of the saved were apparently unaffected; in some cases they had resumed work but suddenly became unconscious and ultimately died. Others made a slow recovery, never wholly recovering or regaining their faculties. A remarkable feature in these cases is the complete aberration of memory from which the victims suffer. They do not recollect a single incident that occured on the day of the disaster. Some of these men, with many others, were engaged in a district that was perfectly unaffected by the catastrophe. They lost their lights, and were stupefied by the concussion, but escaped to daylight without difficulty in a pure current of air. In such cases, concussion, and not the inhalation of poisonous gases, seems to have been the cause of death or of mental affliction.

Mr. Blakemore had contributed an exceedingly useful paper and one that raised important questions demanding further investigation.

Mr. Francis H. Shepherd (Nanaimo, British Columbia) wrote that there were a number of suits for damages against the Crow's Nest Pass Coal Company resulting from the explosion, and now before the court; and as the cases were *sub judice*, the members would readily appreciate that an immediate discussion of Mr. Blakemore's paper might prejudice the case, either one way or the other, if participated in by those who were to give evidence thereon. Under these circumstances therefore, he was restricted, for the present, to making some corrections of mistakes appearing in the paper.

"The other theory, put forward by the management and

supported by the Government experts, is that at the face of the MacDonald level, at D, where a small feeder of gas was known to exist, and was found still to be giving off gas after the explosion."* . . . "It was known to exist a long time before the occurrence of the explosion, but it was so feeble that it could not be detected by a lamp, even when the lamp was held close to it, and one of the men, an experienced miner, who gave evidence, testified that the only way he could devise was to place his ear close to the feeder. . . . ."†

He (Mr. Shepherd) referred the members to the report made to the Government, to the drawing in Mr. Robertson's report,‡ shewing the feeder of gas in the face; to his (Mr. Shepherd's) report and the enlarged plan and section of the face of the MacDonald level;§ and to Mr. Faulds' report and a smaller plan and section of the same level.¶ The feeder could be distinctly heard and felt during their (Mr. Faulds' and Mr. Shepherd's) inspection sixteen days after the explosion, and there could not possibly be any evidence of its volume at the time of the explosion, for no workmen escaped from No. 2 mine.

The MacDonald level was worked two shifts daily, and the feeder issued only 23 inches from the back of the holing in the top coal and on a level with the bottom bench. The amount of coal mined from this holing did not exceed 22 cubic feet (between the blower and the back of the holing) or less than 1 ton. No loose coal was lying to be loaded, and a loaded car was standing at the face: the time being 7·30 p.m., past the middle of the shift. Therefore, the only possible conclusion that could be drawn from the above facts was that this feeder was uncovered during that shift. He (Mr. Shepherd) had no hesitation in asserting that there was no living witness who was aware of the presence of the blower previous to the explosion. There could be no controversy as to the fact of this feeder having been liberated by the holing during the afternoon of May 22nd, and very probably nearer to the time of the explosion than to the commencement of the shift.

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 453.

† *Ibid.*, page 456.

‡ *Reports of the Fernie Coal-mines Explosion*, 1902, page 17.

§ *Ibid.*, page 32. ¶ *Ibid.*, page 68.

"Matches were found in the pockets of some of the miners, as well as pipes and tobacco, but none were found in the pockets of the men recovered from the MacDonald level."* Evidence was given by the man, who washed and dressed the bodies, that matches were found upon the body of one of the two men working in the face of the MacDonald level.

"There is the further consideration that no prospective headings were in operation, which could unexpectedly tap a large feeder."† The MacDonald level and its parallel, the Alder or Beaver level, were distinctly advance-headings, and were advanced further into the solid coal than any other winning drives in No. 2 mine.

Mr. S. L. THACKER'S paper on "The Dynamics of the Winding-engine" was read as follows:—

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 454.

† *Ibid.*, page 454.

THE DYNAMICS OF THE WINDING-ENGINE.

By S. L. THACKER.

Introduction.—The winding-engine is the most important and the most costly portion of the extensive plant which forms the equipment of a modern mine, and in view of the attention which is being directed towards economy in fuel-consumption at mines, the writer feels that no apology will be necessary in submitting a paper upon such a subject.

General Theory.—The total work performed by a winding-engine in raising a load up a shaft, exclusive of friction, may be divided into three parts :—(*a*) Work done in raising the net unbalanced load against the force of gravity; (*b*) work done in imparting acceleration to the whole mass to be set in motion, exclusive of the pulleys and the engine itself; and (*c*) work done in imparting acceleration to the pulleys and drum of the engine.

The reason for treating (*b*) and (*c*) separately will appear later on, and it will be shown that (*c*) is a considerable proportion of the total work.*

* The following notation is used in the various formulæ, and any symbols having special significance are noted in the context :—

L, unbalanced load, in pounds, on the engine at the commencement of the wind.
l, weight, in pounds, of coal raised.
l_c, weight, in pounds, of one cage, tubs, chains, detaching-hook, etc.
l_r, weight, in pounds, of one rope.
w_r, weight, in pounds, of rope per foot.
W, total weight, in pounds, to be set in motion, exclusive of the engine and pulleys.
W_d, weight, in pounds, of the drum and pit-head pulleys.
S, length, in feet, of the wind.
S_t, distance, in feet, travelled by the ascending cage in the time, t.
d, diameter, in feet, of the cylindrical drum.
r_s, minimum radius, in feet, of the spiral drum.
r_l, maximum radius, in feet, of the spiral drum.
r, radius, in feet, of the cylindrical drum
r_g, radius, in feet, of gyration of the drum.
v, maximum velocity, in feet per second, of the ascending cage.
v_g, maximum velocity, in feet, of the radius of gyration.
a, acceleration, in feet per second.
f, increase in the radius, in feet, of the spiral drum per revolution.
t, time, in seconds, in which the maximum velocity, v, is obtained.
g, 32·2.
π, 3·1416.
n, number of revolutions of the engine per wind.
n_t, number of revolutions in time, t.
M, net moment of the load in foot-pounds.
P_i, initial pressure of steam in the cylinder, in pounds per square inch.
P, average effective pressure of steam in the cylinder, in pounds per square inch.
N, number of cylinders.
D, diameter of the cylinder required, in inches.
E, mechanical efficiency of the engine, from 0·70 to 0·85. The efficiency will depend upon the design, construction, and finish of the engine, valve-gear, etc. The figures given are based upon data available for engines of modern construction.

It is assumed that the acceleration from rest to the maximum speed of winding is uniform : this in many cases is not exactly so, but the accuracy of the calculations will not be affected, as an excess at the commencement will be counterbalanced by a subsequent diminution.

Case I.—Coupled winding-engine, with a cylindrical drum, and the winding-rope unbalanced :—L equals $l+l_r$, and W equals $l+2l_c+2l_r$.

FIG. 1.—HIGH-PRESSURE CYLINDERS OF A FOUR-CYLINDERED COMPOUND WINDING-ENGINE.

(*a*) Since the weight of the ascending rope is gradually decreasing and that of the descending rope increasing, there will be a gradual reduction of the unbalanced load, L, throughout the wind, and the mean reduction in time t will be :—

$$\frac{vt}{2} \times w_f \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and the mean load during the time, t, is :—

$$L - \left(\frac{vt}{2} \times w_f\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The foot-pounds of work in overcoming gravity is :—

$$A = \left(L - \frac{vt}{2}\, w_f\right) \times \frac{vt}{2}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

(*b*) The foot-pounds of work done in giving acceleration to the total weight, W, is :—

$$B = \frac{Wv^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

(*c*) The foot-pounds of work done in giving acceleration to W_d will depend upon the radius of gyration of the drum and pulleys.* Approximately, r_g may be considered equal to $r\sqrt{2}$, and the maximum velocity:—

$$v_g = \frac{vr_g}{r}, \text{ and} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$C = \frac{W_d v_g^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Therefore, the total foot-pounds of work to be done in t seconds is:—

$$\left(L - \frac{vtw_r}{2}\right)\frac{vt}{2} + \frac{Wv^2}{2g} + \frac{W_d v_g^2}{2g} \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The work done by the engine in the same time will be:—

$$D^2 \times 0{\cdot}7854 \times P \times \frac{4D}{12} \times N \times \frac{vt}{2 \times d \times 3{\cdot}1416}, \text{ or} \quad . \quad . \quad (8)$$

$$\frac{D^3 \times P \times N \times vt}{24 \times d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$\text{And, } D = \sqrt[3]{\frac{\left[\left(L - \frac{vtw_r}{2}\right)\frac{vt}{2} + \frac{Wv^2}{2g} + \frac{W_d v_g^2}{2g}\right] 24 \times d}{P \times N \times vt \times E}} \quad . \quad . \quad (10)$$

This formula makes the stroke twice the diameter, a very satisfactory proportion; but, if any other ratio be desired, it can be substituted for $4D/12$ in the equation (8).

Case II.—Coupled winding-engine, with a cylindrical drum and balance-rope under the cages.

L equals l, and is constant throughout the wind: and W is increased by the weight of one rope, and equals $l + 2l_r + 3l_r$.

$$A = \frac{Lvt}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

B and C are valued as in the equations (4 and 6).

* To accurately determine the radius of gyration it would be necessary to estimate the moments of inertia of each portion of the drum about the horizontal axis. The sum of these moments, divided by the mass, would give the square of the radius of gyration.

$$\text{And, } D=\sqrt[3]{\frac{\left(\frac{Lvt}{2}+\frac{Wv^2}{2g}+\frac{W_d v_g^2}{2g}\right)\times 24\times d}{P\times N\times vt\times E}} \quad . \quad . \quad . \quad . \quad (12)$$

Case III.—Coupled winding-engine, with a spiral drum.

(*a*) The calculations in this case are considerably more complex, owing to the fact that the ascending load is being wound on a constantly increasing diameter and the descending side the reverse. If the net moment of load, M, is to be constant throughout the wind the following equations will hold good :—

$$r_s\,(l+l_c+l_r)-r_l\,(l_c)=r_l\,(l+l_c)-r_s\,(l_c+l_r), \quad . \quad . \quad (13)$$

$$r_s\,(l+2l_c+2l_r)=r_l\,(l+2l_c), \quad . \quad . \quad . \quad . \quad . \quad (14)$$

$$\text{and, } \frac{r_l}{r_s}=\frac{l+2l_c+2l_r}{l+2l}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

FIG. 2.—HIGH-PRESSURE CYLINDERS OF A FOUR-CYLINDERED COMPOUND WINDING-ENGINE.

The length of spiral, S, for n revolutions of the drum may be taken as :—

$$s=n\pi\,(r_s+r_l), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

$$f=\frac{r_l-r_s}{n}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

$$s_l=n_l\pi\,(2r_s+fn_l), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

$$\text{and, } n_l=\sqrt{\frac{s_l}{\pi f}+\left(\frac{r_s}{f}\right)^2}-\frac{r_s}{f}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

By the equation (13):—

$$L = (l + l_c + l_r) - \frac{r}{r_s}(l_c), \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

$$M = L \times r_s, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

also $$M = r_s(l + l_c + l_r) - r_t(l_c), \quad . \quad . \quad . \quad . \quad . \quad (22)$$

and $$A = M \times 2\pi n_t. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

If the drum be so constructed that the moment of the load is not constant, then it will be necessary to estimate the mean of the moments at the commencement and end of the time, t.

The radius of the drum on the ascending side at the end of t seconds is:—

$$r_t = r_s + f n_t, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

and on the descending side, it is:—

$$r_{t_1} = r_l - f n_t. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

The weight of the rope on the ascending side at n_t revolutions:—

$$l_{r_1} = (n - n_t)\pi(r_t + r_l) \times w_f, \quad . \quad . \quad . \quad . \quad (26)$$

and on the descending side:—

$$l_{r_2} = n_t \pi (r_{t_1} + r_l) \times w_f. \quad . \quad . \quad . \quad . \quad . \quad (27)$$

The moment at the commencement of the wind is:—

$$M_1 = r_s(l + l_c + l_r) - r_l(l_c). \quad . \quad . \quad . \quad . \quad (28)$$

The moment at n_t revolutions is:—

$$M_2 = r_t(l + l_c + l_{r_1}) - r_{t_1}(l_c + l_{r_2}). \quad . \quad . \quad . \quad (29)$$

The mean moment, M equals $(M_1 + M_2) \div 2$; and as before:—

$$A = M \times 2\pi n_t. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

(*b*) Owing to the ascending and descending cages travelling at different speeds, although the maximum velocities will not be widely different, still, to be accurate, each side should be estimated separately. On the ascending side, W_1 equals $l + l_c + l_r$, and the maximum velocity is v; on the descending side, W_2 equals $l_c + l_r$, and the maximum velocity is:—

$$v_1 = \frac{v \times r_{t_1}}{r_t}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (31)$$

$$\text{and } B = \frac{W_1 v^2}{2g} + \frac{W_2 v_1^2}{2g}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (32)$$

(*c*) W_d, of course, depends upon the weight of the drum and pulleys. If the maximum radius of the drum be considerably greater than the radius of pulley, it will be more accurate to

estimate the radius of gyration of each, although the weight of the pulleys being so much less than that of the drum the error will hardly be appreciable :—

$$r_g = \frac{r_t}{\sqrt{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

$$v_g = \frac{v \times r_g}{r_t}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (34)$$

$$\text{and } C = \frac{W_d\, v_g^2}{2g}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (35)$$

Finally, the total foot-pounds of work in t seconds, equals :—

$$M \times 2\pi n + \frac{W_1 v^2}{2g} + \frac{W_2 v_1^2}{2g} + \frac{W_d v_g^2}{2g}. \quad . \quad . \quad (36)$$

FIG. 3.—A HORIZONTAL WINDING-ENGINE.

The work done by the engine in the same time will be :—

$$D^2 \times 0{\cdot}7854 \times P \times \frac{4D}{12} \times N \times n_t \quad . \quad . \quad . \quad . \quad . \quad (37$$

$$\text{And, } D = \sqrt[3]{\frac{\left(M \times 2\pi n_t + \frac{W_1 v^2}{2g} + \frac{W_2 v_1^2}{2g} + \frac{W_d v_g^2}{2g}\right) \times 3}{0{\cdot}7854 \times P \times N \times n_t \times E}} \quad . \quad (3$$

Applications.—Having established the principles of the the the reasoning may be applied to the consideration of a poss case.

The required output is 1,500 tons (total material) in 8 h winding or, say, 190 tons per hour. The depth of the wi

* E., 1903, vol. xxvi., page 447.

1,500 feet. The tubs, having a capacity of 12 cwts. of coal and a tare of 5 cwts., are placed 6 in one cage. The boiler-pressure is 120 pounds per square inch. After allowing 20 seconds for banking and changing the tubs, 48 seconds will be the time for an actual wind.

	Pounds.	Pounds.	Notation.
Weight of coal		8,070	l
,, ,, cage	6,720		
,, ,, cage-chains	1,120		
,, ,, tubs	3,360		
		11,200	l_c
Plough steel-rope, 5¼ inches in circumference, with a breaking strain of 120 tons per square inch, and weighing 4¼ pounds per foot ...		6,500	l_r

The first detail to determine is the size of drum. This is controlled by two factors:—The size of the rope as to the diameter, and the depth of the shaft and the angle of lead as to the width. The writer would refer members to a paper by Mr. W. G. Westgarth for a full consideration of this subject.* Reasoning from good practice and various formulæ, it may be assumed that a suitable drum for the above case would be 20 feet in diameter.

Case IA.—A cylindrical, built-up steel drum, with unbalanced winding-rope (Figs. 10 and 11, Plate XI.). The weight of the drum is 20 tons, and the weight of the pit-head pulleys, 4 tons, making a total weight of 24 tons or 53,760 pounds.

		Pounds.
L	$= l + l_r$	$= 14{,}570$
W	$= l + 2l_c + 2l_r$	$= 43{,}470$
W_d	$=$	$= 53{,}760$

As the net load is uniformly decreasing, the speed will gradually increase, practically until steam is shut off; and assuming that 20 seconds are required to bring the engine to rest, we may say:—

	Feet.	Seconds.
Acceleration	696	24
Full speed	232	4
Retardation	580	20
Totals ...	1,508*	48

* Taking v at 58 feet per second.

The total distance, 1,500 feet $= \frac{24v}{2} + 4v + \frac{20v}{2}$.

* *Proceedings of the South Wales Institute of Engineers*, 1899, vol. xxi., page 340.

$$v = \frac{1500}{26} = 58 \text{ feet per second,}$$

$$\text{and } a = \frac{58}{24} = 2{\cdot}416 \quad \text{,,} \quad \text{,,} \quad \text{,,}$$

Decrease of L in t seconds is:—

$$\frac{vtw_f}{2} = \frac{58 \times 24}{2} \times \frac{13}{3} = 3{,}016 \text{ pounds.}$$

Therefore, $A = \frac{(14{,}570 - 3{,}016)\,58 \times 24}{2} = 8{,}041{,}584$;

and, $$B = \frac{43{,}470 \times 58^2}{2 \times 32{\cdot}2} = 2{,}270{,}700.$$

FIG. 4.—A HORIZONTAL WINDING-ENGINE.

The radius of gyration of the drum, r_g equals $20 \div \sqrt{2}$:—

Therefore, $$v_g = \frac{58}{20} \times \frac{20}{\sqrt{2}} = 41 \text{ feet per second;}$$

and, $$C = \frac{53{,}760 \times 41^2}{2 \times 32{\cdot}2} = 1{,}403{,}269.$$

Therefore, $A + B + C = 11{,}715{,}553$ foot-pounds.

Allowing for wire-drawing and back-pressure in the cylinder, should be taken at not more than $\frac{3}{4}P_i$ or 80 pounds per square in

From the equation (10):—

$$D = \sqrt[3]{\frac{11{,}715{,}553 \times 24 \times 20}{80 \times 2 \times 58 \times 24 \times 0{\cdot}75}} = 32{\cdot}3;$$

say, two cylinders, 33 inches in diameter by $5\frac{1}{2}$ feet stroke.

Some engineers are of opinion that the balance of advantages is on the side of a cast-iron drum, owing to the absence of rivets, bolts, etc., and consequent greater rigidity, but the writer is of opinion that the greater weight is a preponderating disadvantage. The writer will now consider the effect of substituting a cast-iron drum.

Case IB.—Cast-iron drum, 20 feet in diameter, weighing about 32 tons. The weight, W_d, would be increased to 80,640 pounds, and substituting this value in the equation (7), then:—

$$A+B+C=\frac{(14,570-3,016)\,58\times 24}{2}+\frac{43,470\times 58^2}{2\times 32{\cdot}2}+\frac{80,640\times 41^2}{2\times 32{\cdot}2},$$

$$=12,417,188 \text{ foot-pounds};$$

an increase of 701,635 foot-pounds in the work to be performed each wind, or about 6 per cent.

If the energy available were limited to the total in the previous case, the time of winding would be increased, thus:—The total energy is 11,715,553 pounds. The total force is (11,715,553 ÷ 696 or) 16,832 pounds; the mean force required to balance the load is 11,554 pounds, leaving a force available for acceleration of 5,278 pounds. The present total momentum to be acquired is ($B + C$ or) 4,375,604 foot-pounds. Therefore, the distance required to attain the velocity, v, will be (4,375,604 ÷ 5,278 or) 829 feet; and the time required to attain the velocity, v, will be [(829 × 2) ÷ 58 or] 28·6 seconds.

In the previous case, a total momentum of 3,673,969 foot-pounds ($B+C$) had to be arrested in 580 feet, hence the force (brake-power and load) equals (3,673,969 ÷ 580 or) 6,334 pounds.

The present total momentum is 4,375,604 foot-pounds, and if the same brake-power be available, the distance required for retardation will be (4,375,604 ÷ 6,334 or) 690·8 feet; and the time required to bring the engine to rest is [(690·8 × 2) ÷ 58 or] 23·8 seconds.

The results may be tabulated as follows:—

		Feet.	Seconds.
Acceleration	...	829·0	28·6
Retardation	...	690 8	23·8
Totals	...	1,519·8	52·4

Owing to the increase in the weight of the drum, unless a greater brake-power were available to arrest the momentum in less

time, the engine would be unable to attain the maximum speed, and there would be an increase in the time of winding of 4 seconds or $8\frac{1}{3}$ per cent.

From information courteously furnished by Messrs. R. Daglish & Co. and Messrs. Thornewill & Warham, the writer has compiled Table I. of the weights of drums. It will readily be understood that the construction and weight of a drum will depend upon the load to be carried and the depth of the wind, but the figures given in Table I. may be taken as fairly representative.

TABLE I.—WEIGHTS OF PARALLEL DRUMS, EXCLUSIVE OF SHAFT.

Diameters. Feet.	Cast-iron. Tons.	Built up of Steel. Tons.
12	15	12
15	20	15
18	24	18
20	26	15*
20	30	20
22	34	23
25	40	26

* For a light load, the drum is constructed with two rings only.

FIG. 5.—A HORIZONTAL WINDING-ENGINE.

Case III.—Cylindrical steel-drum and balance-rope underneath the cages (Figs. 12 and 13, Plate XII.).

	Pounds.
$L = l$	= 8,070
$W = l + 2l_r + 3l_r$	= 49,970
$W_d =$	= 53,760

As before :—

$$A+B+C=\frac{8{,}070\times 58\times 24}{2}+\frac{49{,}970\times 58^2}{2\times 32{\cdot}2}+\frac{53{,}760\times 41^2}{2\times 32{\cdot}2},$$

$$=9{,}630{,}223 \text{ foot-pounds.}$$

This represents a saving of 2,085,330 foot-pounds per wind, as compared with Case IA, or 17·8 per cent., and a corresponding saving in the consumption of steam.

$$D=\sqrt[3]{\frac{9{,}630{,}223\times 24\times 20}{80\times 2\times 58\times 24\times 0{\cdot}75}}=30 \text{ inches.}$$

The engine required will have two cylinders 30 inches diameter by 5 feet stroke.

If the brake-power be the same as in Case I., retardation will be accomplished in 13·4 instead of 20 seconds.*

The results may be tabulated as follows :—

	Feet.	Seconds.
Acceleration ...	696	24·0
Full speed ...	416	7·1
Retardation ...	388	13·4
Totals ..	1,500	44·5

Shewing a net saving of 3·5 seconds per wind, and a smaller consumption of steam.

We will now consider what reduction in the time of winding would be effected if a balance-rope were added to Case IA, when the same engine-power is maintained.

Case IIB.—Since the net load to be raised is less, there will be a greater proportion of the total energy available for giving acceleration and the maximum speed will be attained in less time (Figs. 14 and 15, Plate XIII.). The total force as before is 16,832 pounds, the load-force is 8,070 pounds, leaving a force available for acceleration of 8,762 pounds. The present total momentum to be acquired is (B + C or) 4,013,503 foot-pounds. The distance required to attain the velocity, v, will be (4,013,503 ÷ 8,762 or) 458 feet. The time required for acceleration will be [(2 × 458) ÷ 58 or] 15·8 seconds; and the acceleration, a, will equal ($v \div t$ or 458 ÷ 15·8 or) 3·67 feet per second.

In the first example (Case IA), 20 seconds were required to bring the engine to rest, and the distance was 580 feet.

At the commencement of retardation, the weight on the ascending side is :—Coal, 8,070 pounds, 580 feet of rope or 2,513 pounds,

* See Case IIB.

a total of 10,583 pounds. The weight on the descending side is 920 feet of rope or 3,987 pounds. Therefore, the unbalanced load is 6,596 pounds. At the end of a wind, the weight on the ascending side is coal, 8,070 pounds. The weight on the descending side is rope, 6,500 pounds. Therefore, the unbalanced load

FIG. 6. - A BUILT-UP STEEL SPIRAL-DRUM.

is 1,570 pounds. Consequently, the mean load helping retardation is [(6,596 + 1,570) ÷ 2 or] 4,083 pounds. The total force arresting momentum, as already noted, is 6,334 pounds. Therefore, the net brake-power equals (6,334 – 4,083 or) 2,251 pounds.

Assuming that this brake-power is exerted in the present

instance, and as there is a constant unbalanced load of 8,070 pounds, the total mean force arresting momentum will be (8,070 + 2,251 or) 10,321 pounds.

The present total momentum is 4,013,503 foot-pounds, therefore the distance required for retardation is (4,013,503 ÷ 10,321 or) 388·8 feet; and the time required is [(388·8 × 2) ÷ 58 or] 13·4 seconds.

The results may be tabulated as follows:—

	Feet.	Seconds.
Acceleration ...	458·0	15·8
Full speed ...	653·2	11·2
Retardation ...	388·8	13·4
Totals ..	1,500·0	40·4

There is, therefore, a net saving of 7·6 seconds per wind or 15·8 per cent.

The adoption of a balance-rope will enable full advantage to be taken of expansive working, since, as has been shewn, there will be a greater proportion of the whole wind made at full speed, during which the gear would come into operation.

The work to be done during full speed is (8,070 × 653·2 or) 5,271,324 foot-pounds, and the energy developed by the engine in the same time is:—

$$= P \times 33^2 \times 0{\cdot}7854 \times 2 \times 11 \times \frac{653{\cdot}2}{20 \times 3{\cdot}1416}.$$

And, $$P = \frac{5{,}271{,}324 \times 20 \times 4}{33^2 \times 11 \times 653{\cdot}2 \times 2 \times 0{\cdot}75} = 35{\cdot}9 \text{ pounds.}$$

The back-pressure may be taken at 10 pounds above the atmosphere, that is, 25 pounds absolute. Allowing 5 pounds for the loss of pressure between the boiler and the engine, the absolute initial pressure will be, say, 130 pounds, and the absolute mean pressure will be (35·9 + 25 or) 60·9 pounds.

The ratio-constant is (60·9 ÷ 130 or) 0·468. From a table of constants for the expansion of steam, the ratio of expansion is found to be 6 times, and steam should be cut off at one-sixth of the stroke. Practically, of course, the cut-off would be progressive, and would come into operation before full speed was attained.

Without the balance-rope, full steam is admitted to the cylinder for 928 feet of the wind. With the balance-rope, full steam is admitted for 458 feet, and, say, one-fifth of the cylinder-capacity for 653 feet. That is, full steam for [458 + (653 ÷ 5) or] 588 feet; and a saving of (928 − 588 = 340 feet or) 36·6 per cent.

Hence, under the determined conditions, by the substitution of a balance-rope and expansive working, there ought to be 36·6 per cent. decrease in the consumption of steam, and at the same time, 15·8 per cent. decrease in the duration of winding.

It is not the writer's intention to describe any of the many forms of expansion-gear, several of which have been described in the *Transactions*. There are two methods of operating the gear:—(*a*) By a governor, coming into action after a certain speed is attained; and (*b*) by gearing from the crank-shaft, thus depending upon the position of the cages. The writer prefers the former, as there is then no necessity to throw the gear out of action in the event of shaft-examination or repairs.

FIG. 7.—A CYLINDRICAL DRUM, WITH CAST-IRON RINGS, CHANNEL-STEEL ARMS, AND STEEL-PLATE LAGGING.

Case III.—Balancing the load by means of a spiral drum (Figs. 16 and 17, Plate XIV.).

If the moment of load is to be kept constant, the ratio between the maximum and minimum radii of the drum will be determined by the equation (15):—

$$\frac{r_l}{r_s} = \frac{8{,}070 + 22{,}400 + 13{,}000}{8{,}070 + 22{,}400},$$

whence, $r_l = r_s \times 1{\cdot}427$.

If the minimum diameter be 18 feet:—r_l equals ($9 \times 1{\cdot}427$ or) 12·843 feet; and the maximum diameter is 25·686 feet. The weight of a spiral steel-drum of these dimensions would be about 45 tons, and W_d will equal 49 tons or 109,760 pounds.

The number of revolutions, n, for a depth of 1,500 feet by the equation (16) is [$1{,}500 \div \pi(9 + 12{\cdot}843)$ or] 21·8; and f equals 21·8 or] 0·176 feet.

(*a*) If the maximum speed of 58 feet per second is to be attained in 24 seconds, by the equation (19):—

$$n_t=\sqrt{\frac{696}{3{\cdot}1416\times 0{\cdot}176}+\left(\frac{9}{0{\cdot}176}\right)^2}-\frac{9}{0{\cdot}176}=11{\cdot}15.$$

The net moment of the unbalanced load is:—

$$M=r\ (l+l_c+l_r)-r_l\ (l_c),$$
$$=9\ (8{,}070+11{,}200+6{,}500)-12{\cdot}843\ (11{,}200),$$
$$=88{,}089 \text{ foot-pounds,}$$

and by the equation (23):—

$$A=88{,}089\times 2\times 3{\cdot}1416\times 11{\cdot}15=6{,}166{,}230 \text{ foot-pounds.}$$

(*b*) The radius of the drum on the ascending side after n revolutions is [9+(11·15×0·176) or] 10·96 feet. The radius on the descending side is [12·84−(11·15×0·176) or] 10·88 feet. On the ascending side, $W_1=l+l_c+l_r=25{,}770$ pounds, and $v=58$ feet. On the descending side, $W_2=l_c+l_r=17{,}700$ pounds, and $v_1=(58\times 10{\cdot}88)\div 10{\cdot}96=57{\cdot}5$ feet and by the equation (32):—

$$B=\frac{25{,}770\times 58^2}{2\times 32{\cdot}2}+\frac{17{,}700\times 57{\cdot}5^2}{2\times 32{\cdot}2}=2{,}254{,}827 \text{ foot-pounds.}$$

In this instance, no appreciable error would arise by taking the maximum velocities as the same.

(*c*) The radius of gyration, r_y, is (12·84 ÷ $\sqrt{2}$ or) 9·08 feet; v_y is [(58 × 9·08) ÷ 10·96 or] 48 feet per second; and by the equation (35):—

$$C=\frac{109{,}760\times 48}{2\times 32{\cdot}2}=3{,}926{,}817 \text{ foot-pounds.}$$

And, $A+B+C=12{,}347{,}874$ foot-pounds.

This is a total amount of work only slightly less than that required in Case IB, and represents an increase of 632,321 foot-pounds or 5·4 per cent. on that required by a flat drum, without a balance-rope.

If the engine-power and steam-consumption were limited to that in the first instance, the increase in the time of winding may be estimated as follows:—The total energy available is 11,715,553 foot-pounds.* The total force is 16,832 pounds; the force required to raise the present mean load is (6,166,230 ÷ 696 or) 8,859 pounds; leaving a force available for acceleration of 7,973 pounds. The present total momentum to be acquired is (B + C or) 6,181,644 foot-pounds. Therefore, the distance for acceleration is (6,181,644 ÷ 7,973 or) 775·3 feet; and the time, t, will be [(775·3×2)÷58 or]

* See Cases IA and IB.

26·7 seconds. During retardation, there is a constant moment against the engine of 88,089 foot-pounds, and the number of revolutions for 580 feet equals 7·32. The energy against the load is (88,089 × 2 × 3·1416 × 7·32 or) 4,052,094 foot-pounds. The distance being 580 feet, the mean force is (4,052,094 ÷ 580 or) 6,986·3 pounds; and, as already shewn, the brake-power is 2,251·4 pounds. Therefore, the total force arresting momentum is (6,986·3 + 2,251·4 or) 9,237·7 pounds. The total momentum to be arrested in this instance is 6,181,644 foot-pounds, therefore, the distance required for retardation is (6,181,644 ÷ 9,237·7 or) 669·1 feet; and the time required is [(669·1 × 2) ÷ 58 or] 23·07 seconds.

The results may be tabulated as follows :—

	Feet.	Seconds.
Acceleration	775·3	26·70
Full speed	55·6	0·96
Retardation	669·1	23·07
Totals	1,500·0	50·73

There is therefore an increase of 2·73 seconds in the duration of winding, or 5·7 per cent.

FIG. 8.—A PARTLY CYLINDRICAL AND PARTLY INTERNAL CONICAL DRUM.

Remarks. — This should be a fairly conclusive demonstration of the relative advantages of balancing by a balance-rope or a spiral drum, evidently favourable to the former. The use of a spiral drum entails the further inconvenience of unequal banking, as the full and empty cages are moving at different radii.

If specially constructed ropes were used, so that the minimum diameter might be reduced and a few turns of the spiral only used

at the start, the remainder of the drum being flat, the weight would then be only slightly increased and a small gain would be obtained in the time of acceleration at the sacrifice of the advantages of a constant load: such an arrangement may be used where the shaft-conditions prevent the use of a balance-rope.

Generally, it may be concluded that if the reduction in the moment of the unbalanced load is counterbalanced by a corresponding increase in the work to be done in giving acceleration to the increased weight, no advantage will be gained by the use of a spiral drum.

The details and weights of any proposed construction being known, the results may be calculated by the foregoing formulæ.

Attempts have been made, with considerable success, to combine the advantages of a balance-rope, with a reduction in the weight of the drums by the use of a single driving-pulley, as in the Kœpe system, already described in the *Transactions*.* Owing to the large size of the pulley required to obtain sufficient friction to avoid slip, the reduction in weight is not so marked, although the weight of rope to be set in motion is less.

The Whiting-hoist system combines the above advantages without the liability to slip, and has been adopted very successfully at the deep Calumet and Hecla copper-mines of America, and also on the Rand. Briefly, it consists of two tandem-pulleys, instead of a drum, driven by disc-cranks, connected by a coupling-rod, similar to the wheels of a locomotive, round which the rope passes several times and thence goes to a tail-race and a turn-pulley, by means of which adjustment for different levels may be accomplished, when desired. A paper on this subject, with the results of practical working, would be of much interest to the members.

Compound Winding-engines.—It would be beyond the scope of this paper to enter upon a discussion of the economy to be obtained by the use of compound engines, as that is rather a matter of heat-economy than mechanical efficiency, but it may be remarked that the mechanical efficiency for four cylindered tandem-engines will be less than for two cylindered-engines, owing to the increased friction.

The size of cylinders for compound winding-engines may be determined as follows:—Knowing the initial steam-pressure, ratio

* *Trans. Inst. M.E.*, 1899, vol. xviii., page 450.

of expansion and cylinder-ratio, the mean effective steam-pressure in each cylinder may be easily estimated either by calculations or from tables.

Let A be the area of the cylinder as found by the equations (10, 12 or 38); P_H, the mean effective pressure in the high-pressure cylinder; P_L, the mean effective pressure in the low-pressure cylinder; and R, the ratio of the cylinder-areas. For a two-cylindered compound engine:—$2A \times P = (A_H \times P_H) + (A_L \times P_L)$. But, $A_L = A_H R$. Therefore, $2A \times P = A_H(P_H + P_L R)$; and:—

$$A_H = \frac{2A \times P}{P_H + P_L R}.$$

For a four-cylindered compound engine:—

$$A_H = \frac{A \times P}{P_H + P_L R}.$$

FIG. 9.—A CYLINDRICAL DRUM, WITH CAST-IRON RINGS AND CENTRAL BRAKE-RING.

Engine-tests and Consumption of Steam.—The determination of the consumption of steam by a winding-engine is generally a very difficult matter, owing to the necessity of keeping other engines at work supplied with steam from the same boilers. In several cases the steam-consumption has been calculated from the indicator-diagrams, no account being taken of steam lost by initial condensation, nor of the effects of cylinder-clearance.

The usual basis to which the consumption of steam is referred is comprized in the statement often made that:—The actual work performed by a winding-engine is the raising of a certain unbalanced load a given distance in a given time. As has been shewn in the preceding pages, this may be far from correct, and any consumption of steam referred to this basis will be considerably exaggerated. It is true that the work done in giving acceleration, and afterwards absorbed by the brake, is lost so far as useful effect is concerned; but it is still work done by the engine, and in so far as it is external to the engine itself, should be included in the brake-horsepower.

If L_m be the mean load during full speed, and S_m the distance travelled at full speed, then $L_m \times S_m$ is the work done at full speed: let this quantity equal D.

Then, the actual mechanical work performed by the engine during a complete wind is $A+B+C+D$, and the mechanical horsepower:—

$$M.H.P. = \frac{(A+B+C+D) \times 60}{33{,}000 \times (t + t_m)}.$$

And, $\frac{M.H.P.}{I.H.P.}$ = the mechanical efficiency.

The brake-horsepower may be obtained by subtracting the work done in giving acceleration to the drum from the sum of the quantities $(A+B+C+D)$. Let W_{d_1} be the weight of drum alone. Then, the brake-horsepower is:—

$$B.H.P. = \frac{\left(A+B+C+D - \frac{W_{d_1} v_g^2}{2g}\right) \times 60}{33{,}000 \times (t + t_m)}.$$

From a careful consideration of the previous theory, it will be evident that this is the basis to which the consumption of steam should be referred, when comparing the performances of different winding-engines.

In conclusion, the author tenders his best thanks to Messrs. R Daglish & Company, to Messrs. Markham & Company, and to Messrs. Thornewill & Warham, for the photographs from which the illustrations in this paper have been produced.

DESCRIPTION OF ILLUSTRATIONS.

FIGS. 1 and 2.—The high-pressure cylinders of a four-cylindered compound winding-engine, with vertical low-pressure cylinders. The diameters of the cylinders are: high-pressure, 32 inches; low-pressure, 50 inches; and stroke, 4½ feet. The cylinders are fitted with Corliss valves and reversing-gear, for a boiler-pressure of 120 pounds per square inch. This engine will be fitted with a conical drum, 18 and 11 feet in maximum and minimum diameters, and will raise 2,300 tons in 10 hours from a depth of 1,050 feet.

FIG. 3.—A horizontal winding-engine, with two cylinders, 32 inches in diameter by 6 feet stroke. The double-ported Corliss valves are fitted with Dobson automatic trip-gear, coupled to a high-speed governor giving a variable cut-off from nothing to 0·4375 stroke. The cast-iron drum is 14 feet in diameter by 8 feet wide.

FIG. 4.—A horizontal winding-engine, with two cylinders, 32 inches in diameter by 6 feet stroke. The Cornish valves are worked by cam-bar valve-gear and automatic cut-off, fitted with throw-out gear to give full steam against the engine, if necessary, during the time when the cut-off gear is in operation. The drum will be 16 feet in diameter.

FIG. 5.—A horizontal winding-engine with two cylinders, 28 inches in diameter by 5 feet stroke. The Cornish valves are not fitted with expansion-gear.

FIG. 6.—A built-up steel spiral-drum, 33 and 18 feet in maximum and minimum diameters and 15 feet 8 inches wide. It will wind from a depth of 2,289 feet. The drum-shaft is 24 inches in diameter, and the total weight without the shaft is about 80 tons. If built without a central ring, the weight would be about 60 tons.

FIG. 7.—A cylindrical drum with cast-iron rings, channel-steel arms, and steel-plate lagging, 19 feet in diameter by 8 feet wide. The weight is about 28 tons.

FIG. 8.—A partly cylindrical and partly internal conical drum, 13 feet and 8¼ feet in maximum and minimum diameters, with a central brake-ring. The weight is about 15½ tons.

FIG. 9.—A cylindrical drum with cast-iron rings and central brake-ring, 20 feet in diameter by 7 feet wide. The weight is about 26 tons.

Plates XI., XII., XIII. and XIV. are graphic diagrams plotted from the results of the formulæ in the cases under consideration in the paper, and they present very clearly the work to be done and the horsepower required at any portion of the wind.

The fine lines in the diagrams of work are plotted from the calculations, and the thicker lines are then drawn by carefully equalizing the areas. The curves in the power-diagrams can then be plotted from the measurements given by the diagrams of work.

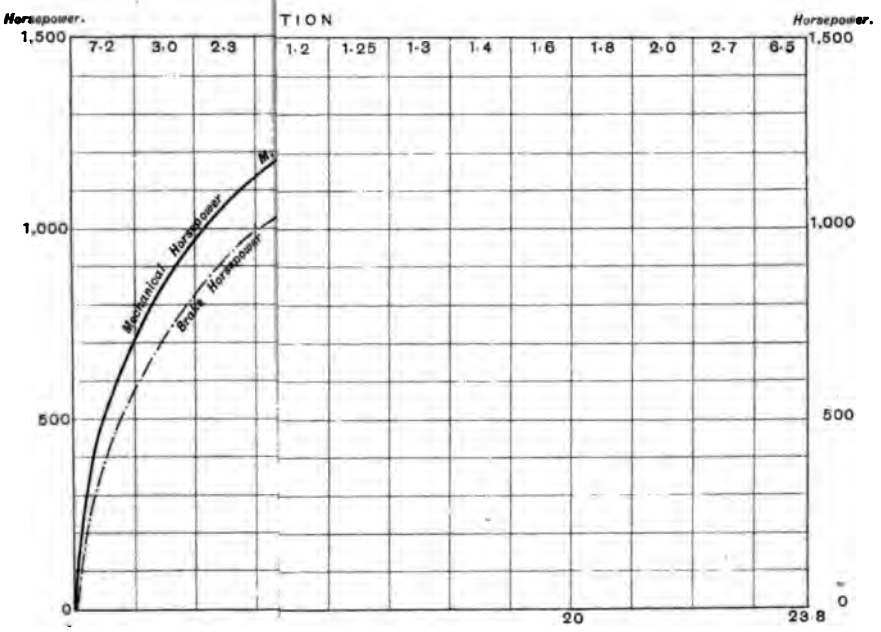
Similar curves might be drawn for any winding-engine that it was desired to test, and on the same diagram, the indicated horsepower, as given by the indicator-diagrams, could be plotted. thus shewing the performance of the engine at any period of winding.

In the case of the spiral drum, it might be thought, as the moment of load is constant, that the load-line should be horizontal; but a little reflection will shew that, although the work per revolution is constant, the distance travelled varies. Hence the force varies in relation to the distance travelled by the cage, and the load-line becomes a sloping curve of large radius.

mics of the Winding-engine."

SECONDS.

GRAM.



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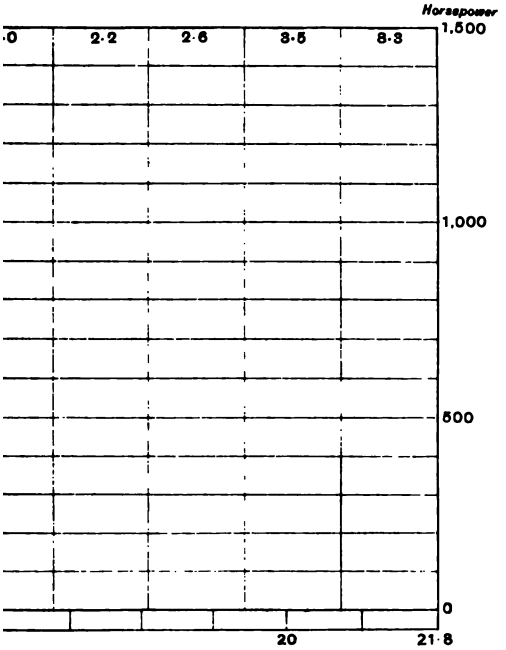

Mr. F. Hird (London) wrote that there were several points suggested by this valuable paper, on which a few remarks might be of interest to the members. It was interesting to note that the mechanical problem in winding was exactly parallel to that which was met with in traction on railways or tramways, and that the methods of calculation in common use for traction were directly applicable to the case of winding. The fact that the traction takes place in a vertical direction instead of in one that is approximately horizontal, of course largely influences the values of the terms which make up the total tractive effort, but the formulæ hold good with scarcely any modification.

In calculating the tractive effort required for a train or street car, there are the following terms:—(1) The friction, which is usually taken as a percentage of the total moving load varying according to track-conditions, average speed, etc., from about 7 pounds to about 30 pounds per ton of moving load. (2) The gravity-component on a grade. This of course is simply the total moving weight multiplied by the gradient. (3) The force required for acceleration: this is the total moving load in pounds, divided by g and multiplied by the required acceleration in feet per second per second. (4) An allowance for additional friction on curves, with which, however, one need not concern oneself in this connection. The total of these terms gives the tractive effort required at any point of the journey. In applying this system to the case of a winding-engine, each term must be considered separately:—

(1) The friction, in many traction-problems, is a very important term, and the selection of the correct constant requires the most careful consideration; but in vertical winding it is an unimportant item and is often neglected, say 10 pounds per ton of moving load may be allowed, though this will scarcely affect the final result.

(2) The gravity-component, in our case, is simply the dead weight of the unbalanced load. If the rope be unbalanced, the tractive effort required at any point of the journey is obtained by adding the weight of the unbalanced part of the rope at this point to the net useful load.

(3) The force for acceleration is the total moving load in pounds divided by g, and multiplied by the required acceleration in feet per second per second. The moving load consists of the

cages, net load, ropes, etc., together with an allowance for drums, pulleys, and other rotating parts, the weight of which must first be reduced to the equivalent weight at rope-speed. This is easily done by taking each part in detail, dividing its weight by the rope-speed squared and multiplying by the actual speed squared. We thus obtain a figure for the total weight supposed to be moving at the rope-speed. In the case of a spiral drum, the process is more laborious: one must then select several points in the journey and repeat the process for each of these points.

This method of considering the problem is handy, and enables one to plot the tractive effort, the speed and the horse-power against time or distance very quickly. The effect of varying the acceleration, maximum speed, or other conditions of the problem can then be seen at a glance.

Should the use of electric motors for winding become general, as he (Mr. Hird) believed would shortly be the case, the method here indicated would be found very suitable, especially when it became necessary to determine the most suitable values for the acceleration and maximum speed: for it must not be forgotten that the electric motor, with its large capacity for overloads, gave a much greater latitude of choice than was possible with a steam-engine.

The author (Mr. Thacker) remarks that the usual basis of consumption of steam per net work done in lifting the useful load is far from correct, since much of the work done is external to the engine. There may be something in this contention, if the tests are taken simply to obtain information about the steam-engine for designers' purposes; but surely the only really practical and commercial test is one, the basis of which is the performance of the winding-engine as a whole. The user is only concerned to know his consumption on the net useful load raised. In any case, the performance of the engine looked at even in the narrower way recommended by the author, depends upon the winding. Rapid acceleration, for instance, may allow of an early cut-off coming into operation sooner, and give a better result in some cases; and the relative shares of the engine and the winding-engine in achieving a given result are inextricably mixed together.

In conclusion, it is interesting and instructive to note how entirely the size of engine is determined from considerations of

maximum effort, and how little room there is for questions of economy. No doubt this is the only available course, and the calculations represent the best practice possible with steam, but it is not surprising that the result in pounds of steam per work done on the useful load should be such as to make the author deprecate this method of expressing results altogether. The moral is plain: keep the steam-engine on a steady uniform load and provide for the fluctuations by power-storage. The means for doing this thoroughly and efficiently are to be found in electrical transmission.

Mr. W. Galloway (Cardiff) wrote that the two subjects dealt with in Mr. Thacker's paper were both included, among others, in a lecture on winding which he had the honour of delivering before the South Wales Institute of Engineers in 1898.* In trying to elaborate a formula from which the diameter of the cylinders could be calculated, Mr. Thacker had endeavoured to include the factor of momentum, but had left friction out of account; and in applying it to a hypothetical case he had taken two-thirds of the steam-pressure, so as to allow for back-pressure and wire-drawing. In discussing the same point, he had made use of a similar formula, namely:—†

$$d = \sqrt[3]{y \frac{(Q + xD)R}{144p}},$$

in which d is the diameter in feet; Q, the useful load in pounds; x, the weight of the rope in pounds per yard; R, the radius of the drum in feet; and p, the pressure of the steam in pounds per square inch. The factor, y, on the other hand, includes all allowances for friction and the momentum of every part of the winding-appliances, and is deduced from actual experiment on a winding-engine working under normal conditions, with a cylindrical drum, in the manner set forth in the paper referred to, in which it is shown to be equal to 2·5 in the case given. He was of opinion that this was a safer method of arriving at a true result than one founded solely upon hypotheses. In the same lecture, he discussed the question of momentum, in practically

* *Course of Lectures on Mining*, 1900, Section 3, page 27.

† The formula is constructed intentionally to make the diameter twice the length of the stroke, but it can be varied so as to vary the ratio in any way desired.

the same way as did Mr. Thacker, and arrived at the same conclusion as to the advantage of a light drum over a heavy one.

The calculations required to arrive at the true proportions of a spiral drum intended to wind from a given depth (which must be determined beforehand) with the greatest economy, require the application of the differential and integral calculus and cannot be carried out with simple algebraic formulæ.

Lastly, it had frequently struck him, in looking at the performances of German and other winding-engines, that the masses to be set in motion and brought to a standstill at the beginning and end of each winding had not been sufficiently taken into account in designing the apparatus, and that much lighter appliances would perform the same work in less time.

Mr. E. H. Roberton (Birmingham) wrote that stress was justly laid by Mr. Thacker, in his valuable paper, on the saving in time and power effected by the use of a balance-rope beneath the cages. It was highly probable that the economy resulting from this or a similar source would form a very important factor in the winding-engine of the near future; but why stop at balancing? Why not overbalance?

The power demanded from the engine, during the period of acceleration, is often as much as 50 per cent. greater than that required if averaged over the whole wind. The surplus required is especially noticeable in the case of a deep mine, where a high velocity is sought for in a short time. Consequently, during the rest of the trip, the engine is working at a power far less than the average power required for the whole trip. Thus, it comes that the tendency of the winding-engine of the present day, owing to the increased depth at which minerals are worked, is towards one which is capable of creating a fairly large acceleration at the outset, and of working expansively during the greater part of the trip. This result is in many cases obtained by the use of two tandem compound engines, which are so constructed that at the commencement of the trip the high-pressure steam can be turned into the low-pressure cylinder, and the high-pressure cylinder exhausted into the atmosphere: the engines being run expansively after the maximum speed is attained.

Now, if some means were devised, by which this great initial

power is spread over the whole trip, or rather to take the energy which is accumulated in the moving masses at the time of highest velocity, and apply it at the beginning of the trip, and (of necessity) to apply it negatively at the end, the power required from the engine would be nearly uniform throughout the greater part of the wind. Further, the brake-power required to stop the masses in motion would be comparatively small. He thought that this arrangement should not be beyond the ingenuity of the present-day mining-engineer. The economical results would be great, both in the first cost of the engine and the boiler-plant, and also in wear-and-tear.

The most obvious way that suggests itself is that of overbalancing. In the case of the ordinary winding-process with a cylindrical drum and unbalanced ropes, the position of equilibrium occurs when the full load is somewhere near the top of the shaft, either above (virtual) or below (actual), and the greatest static load is at the start. In the case of the balanced rope, there is no position of equilibrium, and the static load is constant throughout the wind. In the case of the overbalanced rope and load, the position of equilibrium would occur when the full load is somewhat below the half depth of the shaft. The static load at the commencement would be in favour of the engine, but after passing the position of equilibrium it would be against the engine, and constantly increasing.

The Kœpe system of winding could be (to a limited extent) easily applied to this end, by simply hanging beneath the cages a rope of heavier make than the winding-rope, or perhaps two or more ropes instead of one. A drawback to this arrangement would be that the winding-rope and the driving-sheave would have to be made heavier, and consequently the masses to be set in motion would be increased.

The scroll-drum lends itself well to the solution of the above problem. Taking one of Mr. Thacker's own cases, let the live load be 8,070 pounds, the weight of one rope 6,500 pounds, and the weight of the empty cage and tubs, etc., 11,200 pounds. Thus, a weight of 25,770 pounds is to be overbalanced by a weight of 11,200 pounds. Suppose the diameters of the scroll-drum to be 10 feet and 30 feet. Then, at the start, there is a turning moment in favour of the engines of [(15 × 11,200) − (5 × 25,770) or] 39,150 foot-pounds. This would also be in favour of the brakes at the end of the trip.

The ideal contrivance, for winding, is that which balances the dynamic load as nearly as possible throughout the entire trip. This end will possibly be attained by employing a steadily-running engine, and storing the power by some method of accumulation—electric, hydraulic, or pneumatic—or possibly by devising some combination of a direct winding-engine and an accumulator. The overbalancing previously suggested is a more or less crude attempt at an application of the last-named principle.

The pneumatic system introduced at Épinac by Mr. Blanchet, besides apparently possessing many unique advantages for the purposes of deep winding, offers a solution of the problem of dynamic balance, as there seems no insuperable reason why the exhausting engines should not be kept running steadily throughout the whole working-day. The air in the tube, too, at the beginning of the hoist, would be in a higher state of rarefaction than at the end (when it could be automatically compressed if necessary, to stop the motion of the cage). This seems to suit the case exactly, as the arrangement exerts the greatest power when it is most needed: the power exerted gradually diminishing as the operation of winding progresses.

Mr. S. L. Thacker wrote that he agreed with Mr. Hird, that the method indicated could be easily applied to the consideration of cases of electric winding. Mr. Hird remarked that the user was only concerned with the consumption of steam on the net load raised; but, in comparing the performances of winding-engines, he (Mr. Thacker) thought that it was certainly illogical to disregard the work done in giving acceleration to the cages and ropes, etc.; for, as shewn in his paper, any alteration in the value of W would materially affect the steam-consumption, even if the net load remained the same. An efficiently-designed engine might not necessarily be accompanied by efficient design of all the accessories which make up the complete plant, and a test of the whole installation should not be confused with a test of the winding-engine alone. If comparisons were to be made with other stationary engines, then the value of the mechanical horsepower (M.H.P.) should be taken as the basis of the steam-consumption, while the value of the brake-horsepower (B.H.P.), taking into account as it did the

design of the drum, was, he submitted, the correct basis for comparison of winding-engines working under different conditions.

Previous to writing his paper, he (Mr. Thacker) had not had the advantage of reading Mr. Galloway's lecture, but he had since remedied that omission, and he was glad to find that his deductions generally were in agreement with those obtained by so eminent an authority. It seemed to him, however, that Prof. Galloway, by including all allowances for friction and momentum in one factor (and that obtained by one experiment only), had adopted a much more hypothetical method of calculation than that set forth in the paper. The formula given by Prof. Galloway could be applied only to cases where the conditions were the same as in the test from which the value of y was determined: the formula would not apply to engines with balanced winding-ropes, nor could it be used for spiral drums; and further, it did not lend itself to the determination of the increased power required to wind the same load at an increased speed.

He (Mr. Thacker) could not agree that the calculus was at all necessary for calculations involved by the spiral drum: before adopting the formulæ given in the paper, he had taken the precaution to compare the figures given with those obtained by the calculus, and the difference was so very small that he felt fully justified in using the simpler process.

The suggestion made by Mr. Roberton was certainly a bold one, but he had omitted to note that, by proportioning the drum to give an overbalance at the start, the moment, at the end of the wind, would be enormously increased. Taking the diameters of the drum as he (Mr. Roberton) suggested, namely, 10 feet and 30 feet, the negative moment at the start would be 39,150 foot-pounds; but, at the end of the run, the moment against the engine would be [(15 × 19,270) − (5 × 17,700) or] 200,550 foot-pounds. Under these circumstances, the maximum work per revolution would be at the end instead of at the commencement of the wind, and the size of the engine would be determined by the turning moment during the last revolution. Thus, the mean moment during the last revolution equals 196,125 foot-pounds, and, assuming a mean effective steam-pressure of 100 pounds per square inch,* the size of the cylinder would be:—

* The speed being slower, wire-drawing and back-pressure would be reduced.

$$D = \sqrt[3]{\frac{196{,}125 \times 12}{0{\cdot}7854 \times 100 \times 0{\cdot}75}} = 34{\cdot}2 \text{ inches.}$$

This result compares unfavourably with the previous cases, and there would be the further disadvantage of heavier mechanical construction, owing to the variation of the stresses within such wide limits.

A modification of Mr. Roberton's proposal, which would appear to have some advantages, would be to so construct the drum that the static moments at the commencement of the wind would be in equilibrium. He (Mr. Thacker) had made the necessary calculations for such an arrangement, which, for convenience of reference, might be designated Case IV. (Figs. 18 and 19, Plate XV.).

If the starting moments were to be in equilibrium, the ratio of the diameters of the drum would be:—$r_s \times 25{,}770 = r_l \times 11{,}200$ or $r_l \div r_s = 2{\cdot}301$; and, if the smaller diameter were, say, 12 feet, the larger diameter would be 27·61 feet. The weight of such a drum would be about 53 tons, and W_d would equal 57 tons or 127,680 pounds.

The number of revolutions, n, for a depth of 1,500 feet, by the equation (16) would be [$1{,}500 \div \pi(6 + 13{\cdot}805)$ or] 24·1, and f by the equation (17) would equal 0·324 foot.

(a) If the maximum speed of 58 feet per second were to be attained in 24 seconds, then by the equation (19):—

$$n_t = \sqrt{\frac{696}{3{\cdot}1416 \times 0{\cdot}324} + \left(\frac{6}{0{\cdot}324}\right)^2} - \frac{6}{0{\cdot}324} = 13{\cdot}52.$$

The radius of the drum on the ascending side, at the end of t seconds, by the equation (24) would be 10·38 feet, and on the descending side 9·425 feet. Let S_t equal the distance travelled by the ascending cage in the time, t, and S_{t_1} equal the distance travelled by the descending cage, then:—

$$S_t = n_t\pi\,(r_s + r_t);$$
$$\text{and } S_{t_1} = n_t\pi\,(r_{t_1} + r_l).$$

Substituting the values in the latter equation, S_{t_1} would equal [13·52 × 3·1416 (13·805 + 9·425) or] 986 feet, and S_t, as already determined, equals 696 feet; hence, the reduction in the load on the ascending side in t seconds would be (696 × 4½

or) 3,016 pounds, and the increase on the descending side would be (986 × $4\frac{1}{3}$ or) 4,273 pounds. Therefore:—

$$A = \left(25{,}770 - \frac{3{,}016}{2}\right) \times 696 - \left(11{,}200 + \frac{4{,}273}{2}\right) \times 986;$$

$$= 3{,}736{,}563 \text{ foot-pounds.}$$

(*b*) B might be taken as in Cases 1A and IB, namely, as 2,270,700 foot-pounds.

(*c*) The radius of the drum at 13·52 revolutions, r_t, as already noted, would be 10·38 feet; the radius of gyration, r_g, would be (13·805 ÷ $\sqrt{2}$ or) 9·76 feet; and v_g would equal [(58 × 9·76) ÷ 10·38 or] 54·5 feet per second, and by the equation (35):—

$$C = \frac{127{,}680 \times (54{\cdot}5)^2}{2 \times 32{\cdot}2} = 5{,}888{,}843 \text{ foot-pounds;}$$

and $A + B + C = 11{,}896{,}106$ foot-pounds.
Then, by the equation (38):—

$$D = \sqrt[3]{\frac{11{,}896{,}106 \times 3}{0{\cdot}7854 \times 80 \times 2 \times 13{\cdot}52 \times 0{\cdot}75}} = 30{\cdot}3 \text{ inches.}$$

The engine required would have two cylinders, say, 31 inches in diameter by 5 feet stroke.

TABLE II.

Case.	Time of Wind in Seconds.	Time under Steam, in Seconds.	Total Foot-pounds per Wind.	Average Total Horsepower.
IA.	48·0	28·0	13,463,441	874·2
IB.	48·0	28·0	14,165,076	919·8
IIA.	44·5	31·1	12,987,343	759·3
IIB.	40·4	27·0	12,987,343	874·5
III.	48·0	28·0	14,144,571	918·5
IV.	48·0	28·0	14,057,273	912·8

The net useful work in each case equals $S \times l$ or 12,105,000 foot-pounds.

It would appear from Table II. that the apparent advantages in Case IV. are not sustained by the investigation; and that, even with this modification of Mr. Roberton's suggestion, the total work and steam-consumption per wind would be considerably greater than in Cases IIA and IIB, and would even compare unfavourably with Case IA. It would further be seen from the graphic diagram (Fig. 19, Plate XV.) that the curved load-line, increasing towards the end of

the wind, would increase the difficulty of the application of expansion-gear, and would adversely affect the steam-consumption.

The figures in Table II. further emphasize the fact that, while the net useful work per wind remains the same, the total work and the total horsepower might vary considerably under different conditions.

The CHAIRMAN (Sir Lindsay Wood, Bart.) proposed a vote of thanks to Mr. Thacker for his paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. J. W. FRYAR read the following description of "Sherwood Colliery Sinking":—

The Institution of Mining Engine
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...ics of the Winding-engine."

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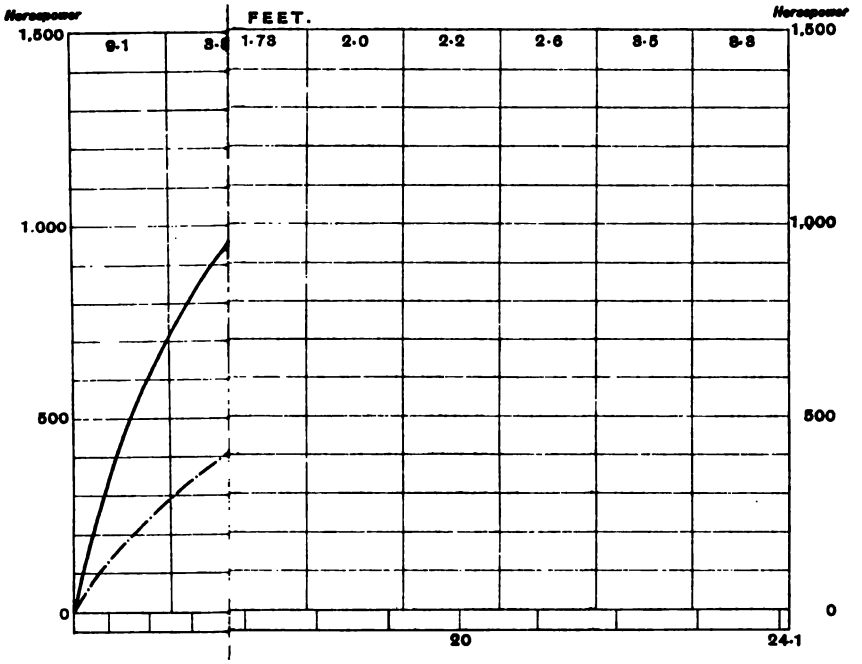
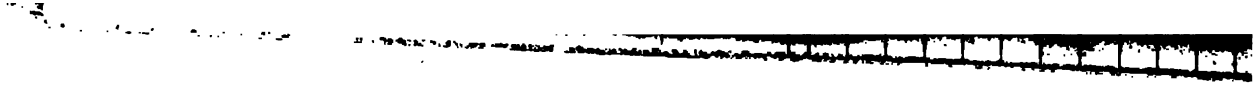
... SECONDS.

...IAGRAM.





SHERWOOD COLLIERY SINKING.*

By J. W. FRYAR.

The outline and position of the shafts and buildings are shewn in Fig. 1 (Plate XVI.).

The finished diameter of both shafts is 20 feet.

Sinking operations began at the upcast or No. 2 pit on March 10th, 1902. The Top Hard coal-seam was reached on March 23rd, 1903, at a depth of 1,302 feet. The total time occupied (including 10 weeks of delay in waiting for tubbing) was, therefore, 54 weeks. Of this time, 33 weeks (including the 10 weeks' stop) were occupied in sinking the first 444 feet, and putting in the coffering and tubbing. The remaining 858 feet were sunk and bricked in 21 weeks, the average rate sunk and bricked being 40·8 feet per week.

The foundations and brick-pillars for the permanent pulley-legs were built, and upon these was erected a temporary wooden head-gear. A landing-stage for dirt was made 15 feet above the level of the ground. The pit-top was covered with folding-doors worked by a small steam-cylinder. When the hoppit came to the bank, these doors were shut, and a side-tip wagon run upon them. The dirt was tipped into this wagon, and the wagon run off. The doors were then opened to allow the hoppit to descend the pit. The side-tip wagon was run to a side-shoot and emptied into railway tip-wagons. A similar set of folding-doors and a steam-cylinder were placed on the ground-level for use when sending down materials, etc. (Figs. 2 and 3, Plate XVI.).

* A short description (*Trans. Inst. M.E.*, 1903, vol. xxv., page 134.) of the plant, etc., was prepared for a visit of the Midland Counties Institution of Mining Engineers, and these additional notes may be of interest to the members.

The sinking hoppits were 4½ feet deep by 5 feet in diameter, and contained about 3 tons of dirt (Figs. 4 and 5, Plate XVI.).

For bricking, a circular scaffold was used, 19¾ feet in diameter, and with a hole in the centre 7½ feet square, through which the hoppit worked when sinking. The scaffold was suspended by two locked-coil ropes from a double-drum winch, and was never taken out of the pit (Figs. 6 and 7, Plate XVI.). The hoppit was steadied in the shaft by a rider, through which the detaching-hook could operate, running on two scaffold-ropes (Figs. 8, 9 and 10, Plate XVII.).

The shaft was timbered systematically as the sinking proceeded, steel timbering-rings, 4 inches wide by 1 inch thick, being inserted at intervals of 3¾ feet, and backed with poling-boards, 4 feet long and 1⅛ inches thick: these were taken out when the shaft was lined.

The first 141 feet were sunk through Magnesian Limestone. The shot-holes were drilled by compressed-air percussive drills, worked from a Walker shaft-sinking frame. All the shot-holes were set out systematically from the centre-line:—6 inner sumper-holes, 6 feet deep and 2 inches in diameter, were drilled in a circle of 4 feet radius; and 16 outer sumper-holes, 6 feet deep and 2 inches in diameter, were drilled in a circle of about 9 feet radius. The whole of these inner and outer sumper-holes were fired together by electricity, and the débris cleared away. Then, 24 side-holes 6 feet deep and 1¼ inches in diameter, were drilled at a radius of 11 feet. These side-holes were all fired together, and left the shaft-side quite clean, and practically no dressing was done by the pick. The average rate of sinking only through this limestone was 22½ feet per week (Figs. 11 and 12, Plate XVII.).

In the softer Coal-measures, 5 sumper-holes, 7 feet deep and 2 inches in diameter, were drilled in a circle of 4½ feet radius: and 10 outer sumper-holes, 7 feet deep and 2 inches in diameter, were drilled in a circle of 10 feet radius. The remaining 16 inches of rock were dressed off by hand when the ground was soft; and where hard rocks were encountered, side-holes, 6½ feet deep and 1¼ inches in diameter, were drilled as in the limestone (Fig. 13, Plate XVII.).

The first 101 feet from the surface were lined with brick-coffering, 14 inches thick at the top and 30 inches thick at the bottom. An outer ring of brickwork, 4½ inches thick, was built and packed behind with soil. Inside this ring, a 2 inches cavity was left, and the brickwork was built solid, with broken joints, to the finished diameter of the pit. Inside the cavity, sheet-iron plates were placed, and the cavity was then filled in with cement-grouting (Fig. 14, Plate XVII.).

Below the coffering, the shaft was tubbed down to a depth of 303 feet, the tubbing being ⅞ inch thick at the top, and 1⅞ inches at the bottom. For the first 117 feet of this depth, the plates were 2½ feet deep with 12 segments to the circle, and the remainder were two feet deep with the same number to the circle. The tubbing was 6 inches wide on the bed (Fig. 15, Plate XVII.).

Fig. 16 (Plate XVII.) shews a section of a bricking-crib, a water-garland, and the brickwork lining of the shaft.

The shaft-bottom is lighted with an electric shaft-lamp comprizing six incandescent lamps of 32 candlepower, suspended by an armoured cable from a special hand-winch.

The double-drum capstan to raise and lower the scaffold has two cylinders, 14 inches in diameter by 20 inches stroke, connected, by double purchase-gear, to a double-drum 5 feet in diameter on the barrel.

The permanent winding-engine for the upcast pit was used for sinking, and consists of two high-pressure steam-cylinders, 26 inches in diameter by 4½ feet stroke. It is fitted with Corliss valves, Seymour cut-off gear, steam-reverser, Whitmore steam-brake, and over-winding prevention-gear. The drum is 11 feet in diameter. A test was made of this engine on June 20th, 1903, when winding at full speed from a depth of 1,260 feet. The weight of hoppit and dirt was 4 tons, and of the rope 23 pounds per fathom. The total time of the wind was 42 seconds, and specimen-cards are shown in Figs. 17 to 22 (Plate XVII.). The estimated steam-consumption, taken from these cards, was as follows:

Revolutions.	Pounds of Steam per Horse-power per Hour (estimated).
1-3	47
4	38
5	32
6-32	25
33	36
34	51

The average indicated horsepower from the sixth to the thirty-second revolution was 900.

The downcast or No. 1 pit was equipped for sinking in a similar manner to the upcast pit. The scaffold-capstan was a duplicate of that at the upcast pit, but the sinking-engine consisted of a pair of ordinary slide-valve cylinders, 20 inches in diameter by 3 feet stroke, geared, 3 to 8, to a drum 8 feet in diameter.

This pit has been lined with coffering to a depth of 107 feet, tubbed to a depth of 351 feet, and lower down it is lined with brickwork, 14 inches thick. The shaft is now sunk to a depth of 1,200 feet.

The permanent winding-enginehouse for this pit is built, and the engine-beds are nearly ready for the engine which will be delivered in the course of a few days. The engine is of the cross-compound type, having cylinders 32 inches and 53 inches in diameter by 5½ feet stroke. It is fitted with Corliss valves, automatic cut-off gear, Whitmore steam-brake, steam-reversing and over-winding prevention-gear. The drum is partly conical, having two dead coils: five working-coils, on a cone rising from 11 feet 8 inches to 12 feet 2 inches in diameter; the next 2½ coils are on a cone rising from 12 feet 2 inches in diameter to 16 feet; after which the drum is flat.

The power-house contains two Robey compound-engines, each with cylinders 11½ inches and 18½ inches in diameter by 2 feet stroke. One engine drives a 50 kilowatts triphase dynamo, and a ventilating fan, 3 feet in diameter, for ventilating the sinking pits. The second engine drives a duplicate dynamo and a 50 horsepower belt-driven Riedler air-compressor. The shop-machinery, mortar-mills, stone-breaker, and a duplicate fan are

driven by triphase motors, the current for them and also for the electric lighting being supplied from these dynamos.

At the end of the power-house, a compound, Corliss valve, fan-engine has just been erected, with cylinders 14 inches and 27 inches in diameter by 3 feet stroke. The steam-pipes are arranged so that either cylinder can be worked without the other. The fly-wheel is 14 feet in diameter, grooved for nine ropes, $1\frac{3}{4}$ inches in diameter, and they work on a fan-pulley 6 feet 8 inches in diameter. The double-inlet Capell fan, 15 feet in diameter by 8 feet wide, is capable of exhausting 300,000 cubic feet of air per minute at 4 inches of water-gauge, when the engine is running at 90 revolutions per minute.

The permanent engine-houses are fitted with overhead travelling-cranes.

The boilers are of Lancashire type, 9 feet in diameter by 30 feet long, fitted with Bennis stokers, Green economizers and Dixon superheaters. The boilers are built to work at a pressure of 150 pounds per square inch, as it is intended to have a pressure of 120 pounds per square inch at the cylinders. The boilers are fed by Knowles compound boiler-feed pumps, in duplicate.

A chimney, 8 feet in diameter by 150 feet high, is being erected.

A central condensing-plant, to condense the steam from all the engines, will be erected in the course of a few months.

The temporary workshops comprize a blacksmith's and fitting shop, a joiner's shop, a saw-shed, a stonebreaker-shed, a tackle-house, a general store, and an oil-store. The blacksmith's and fitting shop contains two forges, a steam-hammer, a planing-machine, a screwing-machine, a lathe and a drilling-machine. The joiner's shop contains a band-saw. The saw-shed contains a circular saw, 4 feet in diameter, and a wood-planing and thicknessing machine. There is a Blake-Marsden lever-action stone-breaking machine. The mortar-mill shed and cement-house, placed close to No. 1 pit, contain two mortar-mills, one 9 feet in diameter and the other, 7 feet in diameter.

The upcast pit has been completed, and the permanent steel headgear is being erected.

A small Riedler pump, capable of forcing 50 gallons per minute against a head of 1,600 feet, is being placed at the bottom of the upcast pit to deal with a small feeder of water which has been met with at a depth of about 750 feet.

Mr. S. A. EVERETT (Gedling) said that a number of attempts had been made to substitute power-drills for hand-work in a sinking-pit bottom, but, except in one or two instances when very hard ground was encountered, they were not attended with any considerable measure of success. The principal objection to their use lay in the difficulty of setting and removing them rapidly; but the arrangement described in the paper appeared to overcome this admirably. He was not quite clear, however, from Mr. Fryar's description, whether the sinking-frame was hung below the bricking-scaffold on the same ropes, or whether separate ropes were used for it. He would also like to know what was the number of men employed in the pit-bottom at one time, the number employed when bricking was being done, and the nature of the material used for "back-filling."

There had been a certain amount of controversy as to the best means of closing the top of a sinking shaft—whether to use the customary running bridge or to employ doors. Where scaffold-ropes were used as guides, the use of a bridge became difficult, if not impossible, and doors were necessarily employed. He knew sinkings where doors had been tried, and had been replaced by a bridge, as they were found to be too slow: but, personally, he gave the doors a decided preference. He did not think that a steam-cylinder was essential in connection with the use of doors, and if the doors were properly balanced and the levers arranged as they ought to be, it was easy for the banksman to manipulate the doors with one hand. The convenience must be apparent of having two landing-stages at the top of the shaft, the upper one for tipping the rubbish, and the lower landing for sending down materials. In the sinking of Gedling colliery, with which he had been connected, a different arrangement for getting rid of the dirt had been used, and he (Mr. Everett)

Folding Doors at Top of Sinking-Pit.

Fig. 2.—Elevation.

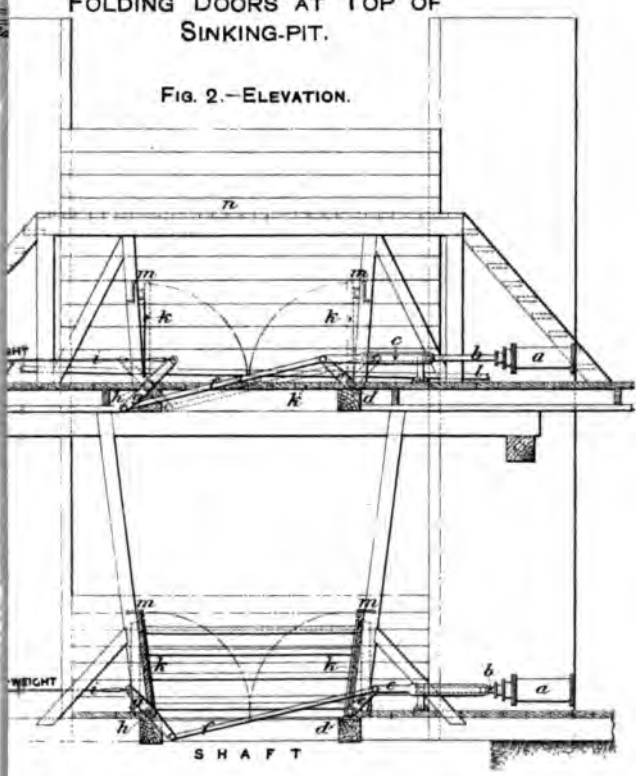
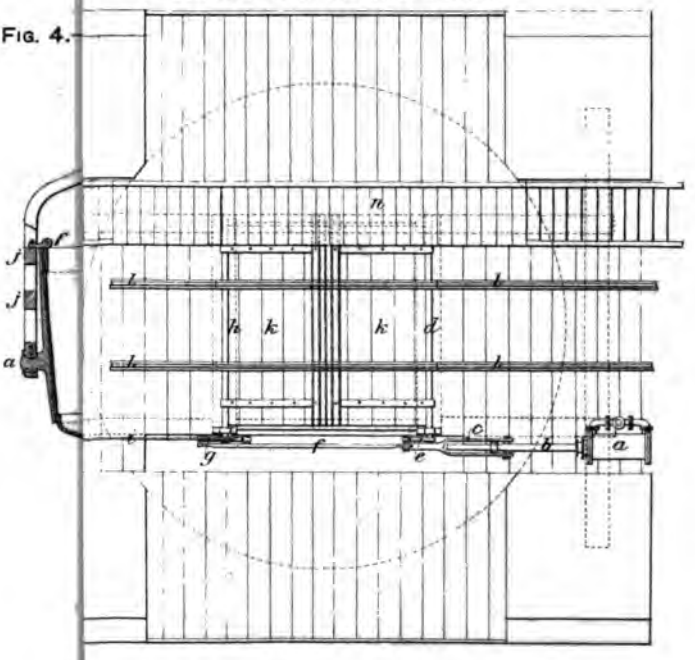


Fig. 3.—Plan, shewing Staging at one Side and Levers at the other Side.

Fig. 4.



GUI…

FIG…

FIG. 13.—PLAN.

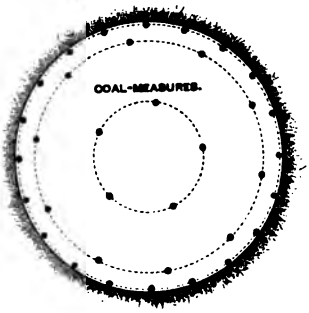
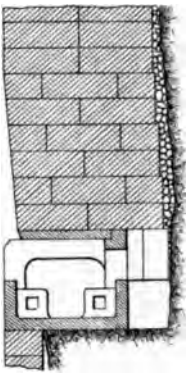
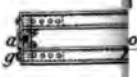


FIG. 16.—SECTION OF BRICKING-CRIB AND GARLAND.



Scale, 2 Feet to 1 Inch.

INDICATOR-CARDS FOR A COMPLETE WIND.



…ounds to 1 Inch.

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FIG. 14.—S…

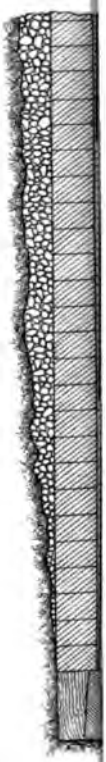


FIG. 20.
REVOLUTIONS NOS. 19 TO 24.

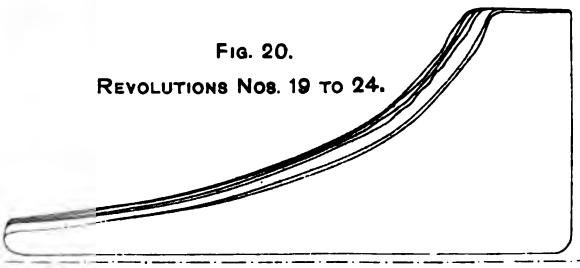


FIG. 21.
REVOLUTIONS NOS. 25 TO 30.

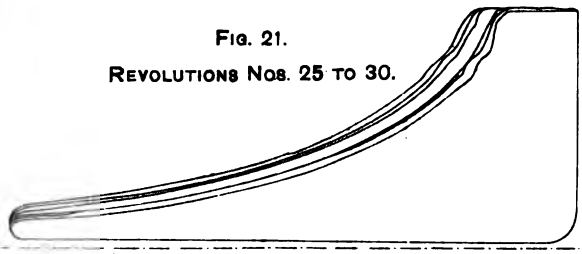
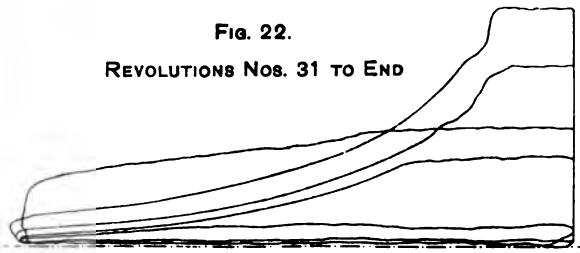
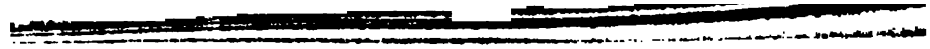


FIG. 22.
REVOLUTIONS NOS. 31 TO END





thought that it possessed some advantages over Mr. Fryar's arrangement. Instead of the doors folding flat together, they met and butted together at right angles to each other. One of the doors was made of light material, and the other formed the continuation of the shoot down which the dirt escaped into the wagons. The hoppit was drawn above the doors, the banksman closed them, and then tipped the contents of the hoppit into the shoot. This arrangement effected a considerable saving of time as compared with a running bridge, and it had worked successfully. In order that the members might appreciate the saving resulting from this arrangement, he might mention that frequently as many as 30 hoppits an hour were drawn to bank when the shafts were from 900 to 1,200 feet deep. The bricking-scaffold used by Mr. Fryar had, he believed, never been put with much success to the use for which it was originally devised by Prof. Galloway. It was intended to enable simultaneous bricking and sinking to be carried on, but in several cases where it had been tried in this way it had been abandoned. The reasons advanced for this were:—(1) The objection of the sinkers to the lime-water from the bricklayers dropping on them; (2) the delay of having to draw up and let down again two sets of men when blasting; (3) the fact that the scaffold went upwards when a length was being bricked, while the bottom of the shaft went downwards, so that a considerable distance soon intervened, and the advantage of the use of the scaffold-ropes for guiding the hoppit was to some extent lost. Although simultaneous bricking and sinking had not been accomplished successfully by the use of the Galloway scaffold, the scaffold possessed undoubted advantages in other respects, and it was now looked upon as part of the equipment of every considerable sinking-operation. The scaffold-ropes were used as guides, and that rendered unnecessary the usual steadying of the hoppit in the bottom of the shaft, besides conducing considerably to the safety of winding. When the sinking at Gedling collieries had reached a depth of 1,400 feet he had tried to determine what saving in time was obtained by the use of the method that he had mentioned, and he had found that it took 3 minutes 5 seconds to steady the hoppit, draw it from the shaft, and return the empty one, whereas when guided these operations could be done in 2 minutes. In addition, the rider

constituted an element of safety against overwinding, because, when it struck against the upper timber of the pit-gear it buckled, and drew the two ropes together, which thus retarded further upward movement of the hoppit.

He would like to know whether Mr. Fryar expected to have any trouble with the large cylinder (53 inches in diameter) of his winding-engine when running at the high speed mentioned in the paper, especially as he would use superheated steam. The compound spiral-cylindrical drum of comparatively small diameter (first introduced, he believed, by Mr. E. M. Hann at the Powell Duffryn collieries) was certainly an excellent form. He asked whether Mr. Fryar intended to use a balance-rope with it. At some future time, perhaps Mr. Fryar would be able to supply the members with information as to the condensing-plant.

Mr. Maurice Deacon (Whittington House, Chesterfield) asked Mr. Fryar whether he could give the members any explanation as to why the coal at Sherwood colliery was found at a depth of 1,300 feet, as a good many people in the district would have been less surprised had it been found at a depth of 1,600 feet.

With regard to sinking with drills worked by compressed air, he (Mr. Deacon) would like to know whether both pits were sunk in this manner, or whether one had been sunk by the ordinary method; and, if so, perhaps Mr. Fryar could give them the comparative costs of both systems. He noticed that Mr. Fryar had stopped the coffering of the shaft at a depth of 100 feet. Why had he not gone deeper before commencing the tubbing? He would like to know also the exact function that the sheet-iron plates, inserted inside the cavity of 2 inches between the outer ring of brickwork and the inner ring, were supposed to perform, also how they were fastened together, bolted or riveted, and whether the joints were watertight.

With regard to the winding-engine fitted with Corliss valves and Seymour cut-off gear, perhaps Mr. Fryar would say whether he used the cut-off gear regularly in sinking, or whether the diagram attached to his paper was only an experimental one.

With regard to the appliances which Mr. Fryar had used, with the object apparently of economizing steam, he (Mr.

Deacon) would like to know whether his calculations as to the saving in fuel in pounds, shillings and pence, taking into account interest, depreciation and repairs, would warrant the use of economizers and superheaters. This was very questionable, for while there was no contesting the fact that such appliances would economize the steam used, it was sometimes a question as to whether such economy was not bought at too high a price, and especially at a colliery where the type of fuel used was somewhat inferior. Mr. Fryar did not state whether the workshops were driven by electricity or by steam-power.

Mr. JOHN MORISON (Cramlington, Northumberland) said that, before offering any criticism on Mr. Fryar's paper, he would first of all like to refer to some remarks made by Mr. Everett with reference to the use of the Galloway scaffold. Mr. Everett had stated that the Galloway scaffold as invented had never been used as it was intended by Prof. Galloway that it should be used—that is, for sinking and bricking simultaneously, and that on every occasion on which an attempt had been made to use it in this way it had been abandoned. He might state that he had at one sinking pit used the Galloway scaffold for sinking and bricking to a depth of 1,650 feet,* and the whole of that work had been done simultaneously, as Prof. Galloway had intended that it should be done. He, therefore, thought it only right that no one should be allowed to take away credit from Prof. Galloway's invention, without a protest.

With regard to Mr. Fryar's paper, he thought that gentleman was to be congratulated upon the high rate of sinking accomplished. He (Mr. Morison) did not know whether this speed was due to the drills employed, or to the efficient method of getting rid of the dirt after shot-firing, and the winding arrangements made for that purpose. Probably, if the matter was looked into properly, the one had as much to do with the speed as the other. He had not seen the sinking-frame in operation, but he did not know from the experience that he had had with these drills that much more rapid work was done with them than by hand-worked drills.

With regard to the coffering, Mr. Deacon had asked why it had not been carried down farther, and the same question had

* *Trans. Inst. M.E.*, 1894, vol. viii., page 118.

occurred to him. He would also like to criticize the system of leaving an open space behind the brickwork. It seemed to him that the more correct system of putting in brick-coffering was to grout the back-course of bricks with the shaft-wall; because when such a system was adopted it left an annular space behind the brickwork, which was exposed to the hydraulic pressure of the water in the shaft-walls, while if the bricks were carefully grouted behind, the pressure was only applied to that part of the brickwork where the water was issuing and not all round as in a cylinder-jacket. The cavity could still be adopted in both systems, but he thought that the method of grouting behind the inner course of brickwork was a very essential part of an operation such as had been described.

Mr. JOHN GERRARD (H.M. Inspector of Mines, Manchester) asked Mr. Fryar whether he had found any difficulty in connection with the rider. He had known of more than one accident having occurred owing to a rider sticking, but they appeared to have been different in form from that described by Mr. Fryar. He would like to know, however, whether the members knew of any cases of a rider sticking. He could, also, give an instance where the Galloway scaffold had been used as intended. It was at Cadeby colliery, near Doncaster, a deep shaft; and the operation had been very successful, both as regarded, safety and the work accomplished.

With reference to the use of drills in sinking, it seemed to him that engineers were old-fashioned and more conservative in this respect than in any other branch of mining. There had been a number of new winnings in Lancashire of late years, and he had been very much interested in going from one to the other and noting the sinking arrangements. Last year, there were three winnings almost adjoining each other going on together. At one sinking, there was no rider, no guide, no skeleton-rings, and no temporary timber, the advantages of which have been seen so many times. Every hole for the progress of the sinking or for the support of the rings was worked by hand, employing three men, two striking and one holding the drill. At the next winning, he found two guides with a rider rather differently arranged from that described by Mr. Fryar so as to enable a safety-hook to operate and also to avoid the risk of

sticking; also skeleton-rings and temporary timber, and the holes put down by hand-machines—not power-machines—one man engaged in drilling the hole, whether sump-holes, side-holes or ring-holes. And then he had gone to a third winning, and found something half-way between the two other sinkings. He had asked the conservative contractor, why he had not adopted the guides, why he had not adopted skeleton-rings and timbering, and why he put down all his holes by hand. And he had replied that with regard to the guide he thought it dangerous; as to the skeleton-rings he liked to see the sides of the shaft and what danger there was; and as to boring by machine-power, while the men were fixing the machine he considered that they could have the hole drilled. Details as to the rate of progress made with the use of machine-drills were supplied to him and compared with hand-driven holes in similar strata, and he had said that he could not believe that it had been done, and he (Mr. Gerrard) was unable to convince him that it had. The Grant electric drill had been tried in the district, with a sinking-frame rather different from and more cumbrous than that described, and they had persevered with it for some time, but it had had to be taken out. They had given it a good trial: it had not been put in only for a day—but they had persevered with it for weeks, and with every desire to improve it and make it a success. The shaft was very wet, the cables became defective and the power frequently failed.

Mr. W. Price Abell (Duffield) thought, with regard to Mr. Fryar's remarks on a central condensing plant, that the paper recently read by Mr. McLaren* in Leeds would be of interest. There he gave results of the leading central electric-light stations and surprised engineers by showing that condensing-stations were not the most economical. This naturally gave rise to a lengthy and interesting discussion, which in a measure qualified Mr. McLaren's returns and showed that although the electric-light station fitted with condensing-plant did not always prove the most economical, the varying load was in some measure answerable for this surprising result. He (Mr. Abell) also remarked on the previous speaker's wish for knowledge as to the amount of water met with; he thought it would interest the meeting to hear what sinking pumps Mr. Fryar had used.

* *Proceedings of the Institution of Mechanical Engineers*, 1903, page 511.

Mr. James Barrowman (Hamilton), with reference to the cavity behind the brickwork in which the sheet-iron plates were placed, asked what was the object of using these plates. He would also like to know whether the drum was a conical or a scroll-drum.

Mr. W. B. Wilson (Easington, County Durham) asked what quantity of water was tubbed back.

Mr. George Spencer (Derby) asked what kind of pumps had been used.

Mr. G. A. Mitcheson (Longton, Staffordshire) asked whether Mr. Fryar had used an alternate arrangement for braking, that was a hand and a steam-brake. He would also like to know what explosives had been used, and whether any difficulty had been experienced with simultaneous firing when so great a number of shots were fired at the same time. Did he use a high-tension or a low-tension system, and were the holes fired from a battery or a dynamo?

With reference to the drum, if Mr. Fryar was going to use a balance-rope, what advantage was there in having differential diameters on the drum? For a drum of medium size, like that at Sherwood colliery, was there any advantage in having the smaller diameter? With reference to the cross-compound engine, he (Mr. Mitcheson) asked Mr. Fryar whether he had an intermediate receiver, or whether he could steam the low-pressure cylinder as well as the high-pressure cylinder when he was doing his manœuvring. With reference to the question of central condensing-stations, he had read Mr. McLaren's paper, but he considered that his statement was very one-sided altogether, and it would not influence him in the slightest so far as the application of condensing to winding-engines at collieries was concerned.

Mr. J. A. Longden (Stanton-by-Dale, Nottingham) said, with reference to the drum 11 feet in diameter, on the permanent winding-engine for the upcast shaft, that the rope could not very well be less than 2 inches in diameter, and that meant 40 revolutions, so that there was 6 feet 8 inches of traverse, and if he was going to have that amount of traverse he would expect that the pulleys would be soon worn out, or the rope

would overlap on the drum, which would cause the drum-lags to be unduly worn where the overlap occurred.

Mr. HENRY W. MARTIN (Dowlais) wrote that the rapidity with which the shafts at Sherwood colliery were sunk and lined showed that the appliances and methods adopted by Mr. Fryar and described by him in his very interesting and instructive paper, were of the most suitable and effective description. It was indeed difficult to take exception to any of them. Rock-drills operated by compressed air, with suitable means for readily fixing and again removing them, greatly expedited the process of sinking through hard ground, and reduce the cost of the work as compared with the old system of hand-drilling.

The most expeditious sinking of pits, with which he was acquainted, in the South Wales coal-field was that of the two pits at the Lady Windsor colliery, Ynysybwl, carried out by Mr. William Jenkins of the Ocean collieries. The diameter of the downcast pit was 19 feet in the clear, and the upcast pit, 17 feet in the clear. They were both lined throughout with brickwork, in no case less than 9 inches thick. The sinking of the pits commenced on January 16th, 1884, and the Four-feet coal-seam was struck on September 4th, 1885. The sinking was completed by the end of January 1886 to a total depth of 1,875 feet, at an average rate of 22·3 feet per week, as compared with 24 feet per week at the Sherwood colliery. Power-drills driven by compressed air were, to a limited extent, used for boring. As was the case at Sherwood colliery, the Lady Windsor pits were sunk without any water-difficulties to retard progress, and the strata were very suitable for rapid work. They both formed very excellent examples of successful sinking.

He considered that the systematic timbering of the sides of the shaft as the sinking proceeded, as carried out by Mr. Fryar, was most commendable. This practice, he believed, was now almost universally adopted. The cost of systematic timbering was more than counter-balanced by the time saved in examining the unwalled sides of the shaft, and in removing or securing ground, which was bad or doubtful, to say nothing of the all-important matter of increased safety to the sinkers working in the bottom of the shaft. It was questionable, considering the very small quantity of water met with

in the limestone, whether the large outlay in cast-iron tubbing was called for, as feeders of water met with during the process of sinking frequently yield much less water after they have been allowed to run freely for a time.

The figures given by Mr. Fryar of the steam-consumption of the 26 inches winding-engine on the upcast shaft were very interesting; and, although they only represented the steam-consumption per indicated horsepower per hour as calculated from indicator-cards, they showed very excellent results, namely, the development of 1 indicated horsepower per hour by the consumption of only 25 pounds of steam. It seemed questionable to him whether the principle of compounding could be adopted with any real advantage in a shaft only 1,250 feet deep. From the unavoidable conditions of intermittent winding, even when the winding-ropes were balanced completely, the load on the engine varied so rapidly and to so great an extent in shallow pits, that it was not possible to expand the steam sufficiently with the heavier load to justify two-stage expansion without expanding it to such an extent as to produce excessive loss when the load on the engine was light.

It was difficult to take exception to anything that Mr. Fryar had done in sinking the shafts, and the same might be said with regard to the permanent equipment of the colliery.

He hoped that the future success of the colliery would be commensurate with the care and skill displayed in sinking and equipping the pits, and that Mr Fryar would accept his hearty congratulations upon his splendid achievements.

Mr. A. H. Stokes wrote that Mr. Fryar would add to the value of his paper, if he gave the name of the explosive and the total quantity used in sinking one shaft. It would be useful to know what object Mr. Fryar had in view when inserting sheet-iron plates between the coffering-rings, and whether the plates were bolted together and made water-tight at the joints. The figures given for the fan were very interesting, for it appeared that the volume of air discharged at every revolution would be about three times the cubical capacity of the fan.

Mr. J. J. Prest (Horden Colliery) wrote that the average rate of sinking the No. 2 shaft at Sherwood colliery appeared to have been about 24 feet per week, including all stoppages.

He would be glad to know from Mr. Fryar whether the sinking was carried on continuously, or whether there was any cessation of work on Sundays. It would be interesting also to know the maximum volume of water encountered in sinking the shafts, and how many wedging-cribs were laid in each shaft: also whether the Walker shaft sinking-frame and drills were used systematically throughout the sinking. If not, what depth in each shaft was sunk with these machine-drills in operation, and what was the relative rate of progress with machine- and hand-drilling respectively? It would also be of interest to know whether sinking and walling were carried on simultaneously in each shaft, and whether any inconvenience was caused to the sinkers in consequence. The first 101 feet from the surface appeared to have been lined with water-tight walling. Information as to the feeders of water met with in sinking to this depth, and the effect of the coffering in totally excluding them from the shaft, would be interesting; also an explanation as to the reason why sheet-iron plates were placed in the cavity, the thickness of these plates, and whether the whole of the circumference of the shaft for the whole extent of the coffering contained these plates. It would appear from the information supplied that there was a feeder approaching 50 gallons per minute to be dealt with at the pit-bottom, and it would be interesting to know whether this feeder of water was the sum-total of the drainage from the tubbing and the coffering.

Mr. W. Galloway (Cardiff) wrote that the sinking of the two shafts at Sherwood colliery forcibly reminded him of the corresponding operations at the two Llanbradach shafts, where all the appliances at the surface of, and within, the shafts were the same—except that, in the case of Llanbradach colliery, only one pair of the folding-doors on No. 2 shaft was opened by a steam-cylinder, and the compressed-air rock-drills stood on tripods instead of on a shaft-sinking frame. After his experience at Llanbradach colliery he concluded that a hydraulic cylinder would open and close the doors better than a steam-cylinder; but, the doors being exactly balanced in every position, not much effort was required to work them, and it was more with the object of saving time and leaving the bankman's hands free to attend to the other operations than with that of saving labour, that

a cylinder need be employed. The employment of a shaft sinking-frame for supporting the rock-drills was an ideal solution of the question; and, judging by the results attained in the speed of sinking, the Walker frame appeared to answer the purpose admirably. The requisites for a perfect frame were stiffness, suitable weight, and facility of being handled, that is, raised and lowered quickly. He had made an unsuccessful attempt to introduce a combined walling-stage and rock-drill frame in the No. 2 pit at Llanbradach; but the rings of H iron, which constituted the supports to the floor of the stage, were not stiff enough to prevent the rock-drills from moving up and down to a small extent under the force of the blows. The attempt was, therefore, abandoned, as it was not considered expedient to procure another heavier and stronger stage. When employed as a frame for the rock-drills, the stage stood on vertical legs, which could be lengthened or shortened by means of screws, and it was heavy enough to remain quite still; but the flanges of the H iron were too elastic, and this circumstance caused the failure.

Mr. J. W. Fryar, replying to the discussion, said that he had never had occasion, as it happened, to use the scaffold and the sinking-frame in the shaft at the same time. Limestone occurred for a depth of 141 feet, and he had only once required the scaffold: then it was for the coffering, and he had thereupon taken out the drilling-machines. The number of sinkers in the shaft at one time varied from 16 to 20, the usual number being about 17 or 18; and the number of bricklayers was generally 8. Cement was used for the coffering; and lime-mortar was used for ordinary bricking: the limestone being quarried and burnt on the colliery.

With respect to the question as to the utility of using steam-cylinders for opening the doors at the top of the shaft, when the woodwork of the doors became swollen with water and clogged with dirt, it was as much as the steam-cylinders could do to open them, even with balance-weights attached.

The large winding-engine had been designed to run at 78 revolutions per minute, and he did not anticipate any difficulty with it at that speed. The engine had been designed for winding with a balance-rope below the cages, and he thought it was well worth while to try one, but with this particular form of drum

he was not at all sure that the balance-rope would prove advantageous. He could not give the name of the condensers that he intended to use, as the matter had not yet been settled.

With reference to Mr. Deacon's question as to why the Top Hard coal-seam had been found at a depth of only 1,302 feet, this depth was less than they had expected, but he was not able to give any distinct reason why the coal was not found at a greater depth from the surface. He did not think that it was due to any considerable fault in the neighbourhood, but to the natural formation of the ground.

He had sunk both shafts by the same system, and he could not therefore compare the cost of hand- and power-drilling. Mr. Deacon had also asked why the coffering had not been extended beyond a depth of 101 feet. It had been stopped as soon as the cost of excavating the ground (which was in limestone) and the cost of putting in the brickwork and cement was practically the same as putting in the tubbing and excavating the ground. The sheet-iron plates were placed, overlapping, in the cavity, they were not fastened together, and they were used to ensure that there would be no honeycombing in the cement-grouting.

The Seymour cut-off gear on the winding-engine was used during the whole of the sinking, and the test was taken with the valves under the same conditions as had been in force during the whole time.

He (Mr. Fryar) calculated that there was a distinct saving in fuel and, therefore, in money, from the use of economizers and superheaters; he might also point out that, with economizers and superheaters, fewer boilers were required and therefore, the capital-outlay was no greater with them than without them. He had only used one boiler during most of the sinking.

The plant in the workshops was all driven by electricity. He had a steam-hammer. He intended to use compressed air in the shops, and it might be employed in working the hammer.

He (Mr. Fryar) thought that speed in sinking depended not so much upon the time taken in drilling the shot-holes (although this was very important in hard ground) as upon good judgment in placing and charging the holes, so as to get the ground properly, and upon efficient methods of removing the dirt.

The space left behind the coffering had been criticized by Mr. Morison. With water coming out of the rock, it was almost

impossible to build the outer rim close to the shaft-walling, as the water washed the whole of the mortar and grouting away. The space was filled with crushed limestone, until they got rid of the water; then, at the top, he had put in soil which was washed down among the crushed limestone, until the space between the outer ring and the rock was filled.

There had not been any trouble with the rider sticking.

With regard to the quantity of water encountered, he had given the amount in a previous paper describing Sherwood colliery.* It had never been more than 80 gallons per minute at one time, and the total feeders passed through only equalled 150 gallons per minute.

There was no alternative brake, and the Whitmore steam-brake had been used on the winding-engine during the whole of the sinking. It worked quickly and smoothly, and the engine-man could do anything with it, much better than with a foot-brake.

Gelignite had been used as the explosive, during the whole of the sinking. No difficulty had been experienced with regard to simultaneous firing; low-tension detonators had been used, and fired from the dynamo.

It was expected that the amount of air discharged by the fan during each revolution would be about 1¼ times the cubical capacity of the fan.

The reason for the difference in the diameters of the drum of the winding-engine was that at the beginning of the lift the leverage due to the different diameters gave the engine an assistance to the extent of about 4 tons.

He had erected an intermediate receiver of the re-heater type, and no live steam would be used in the low-pressure cylinder. After the engine had started, it was impossible for the engineman to put live steam into the low-pressure cylinder.

The small drum on the upcast-pit winding-engine had been criticized. A rope 5¼ inches in circumference would be used and the travel on the drum would be about 5 feet 4 inches. The lead would be about 115 feet, and he (Mr. Fryar) did not expect that there would be any unusual wear on the pulley-wheels.

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 134.

The water-feeders had been pumped for several years at a neighbouring colliery and had not lessened to any appreciable extent. The water was very bad and it was cheaper to tub it off than to collect and pump it continually. The total leakage from the tubbing and coffering was ⅓ gallon per minute in each pit.

The PRESIDENT (Mr. J. C. Cadman) moved a hearty vote of thanks to Mr. J. W. Fryar for his interesting paper.

Mr. J. BARROWMAN seconded the resolution, which was cordially approved.

Mr. R. PEARSON's paper on "The Discovery of Natural Gas in Sussex: Heathfield District" was read as follows:—

THE DISCOVERY OF NATURAL GAS IN SUSSEX: HEATHFIELD DISTRICT.

By R. PEARSON.

Occurrences of Natural Gas.—The first find of gas, to the knowledge of the writer, was made in 1836, at Hawkhurst in West Sussex. In sinking a well, after 98 feet of digging, the men commenced to use an auger-bit, working by the light of ordinary lanterns held at the bottom of the well. When the hole reached some 50 feet below the point at which boring was commenced, 148 feet from the surface, the auger suddenly disappeared into a cavity, there was a rush of gas, and two of the workmen were burned to death. This discovery was never followed up.

Natural gas was next found during the famous Sub-Wealden boring of 1873 to 1875, at Netherfield, west of Robertsbridge, on the South Eastern railway to Hastings. It was reported frequently during the boring operations, that there were outbursts and explosions of gas. The writer has cause to believe that the gas found on this occasion was burned for several months. Mr. William Topley, in his *Geology of the Weald*,* records the occurrence at a depth of 602 feet of a bed, 2 feet thick, very rich in petroleum. This was about 312 feet below the top of the Kimeridge Clay, which was reached at about 290 feet below the surface. Mr. Willett in his records of this bore-hole stated† that "slight indications of petroleum have been noticed all through the Kimeridge Clay, but they become more distinct at about 160 feet from the top of the clay (or about 450 feet from the surface); all below that depth is more or less impregnated with petroleum, it being particularly abundant at the following depths (from the surface): 600, 604, 617, 622 and 651 feet. Fossils are scarce or absent in those parts of the clay which are

* Page 43.

† *Sixth Quarterly Report*, page 2.

richest in petroleum." This discovery of gas and petroleum, like the first to which the writer has referred, was not followed up.

But one's surprise at this neglect is lessened on reflecting that natural gas was not used to any great extent in America before 1885. It was about that date that Mr. Andrew Carnegie began to use natural gas in his now world-famed steel-works, and the development of the natural-gas industry of America may be said to date from then. The growth of the use of natural gas in America may be judged by the fact that to-day in the iron-mills, where hundreds of stokers worked in the early eighties,

FIG. 1.—No. 1 BORE-HOLE, NEAR HEATHFIELD HOTEL.

one sees now only a few lads turning on gas-cocks. Wherever gas is available, gas is the fuel for the progressive iron-master.

Seeing that the gas-industry of America practically started in 1885, it is easy to understand why no practical working followed the early discoveries of natural gas in Sussex. They were made a number of years before anything was being done with natural gas in America, and nobody cognizant of the possibilities seems to have heard of the finds.

To revert for a moment to the Sub-Wealden boring, carried on by private enterprise and subsidies from geological societies to prove what underlay the Wealden area, this undertaking was

not a waste of money, as so many people think. Quite close to this bore-hole, to-day, many men are and have been for many years employed in mining some of the finest gypsum produced in the world, which was discovered through this experiment, and the writer has seen some of this gypsum so highly impregnated with petroleum that it could be worked to produce that well-known illuminant.

Some years ago, a firm of well-drillers were boring a well for water at Heathfield, on the site of what is now the Heathfield Hotel. This hotel is situate some 150 feet from Heathfield Station on the London, Brighton and South Coast railway, and stands about 20 feet above the level of the railway-station. At a depth of about 200 feet, the borers met an inflammable gas; but as they were seeking for water, and none being reached the bore-hole was cemented up and abandoned.

A short time afterwards, men employed by the same firm were boring a well for the London, Brighton and South Coast Railway Company, for water to supply the locomotives at Heathfield Station. This bore-hole was sunk in the cutting, at the station-end of the tunnel. In August, 1896, while at work at a depth of about 300 feet, they also found an inflammable gas. But no water was reached, even when another 100 feet had been sunk. The casing-tubes were withdrawn, except a few at the top of the hole, and once more work was discontinued. The discharge of gas, however, continued for three years, and was lit from time to time, to gratify the curiosity of visitors.

About that time (1899), the railway company decided, as the supply was not diminishing, to put the gas to some useful purpose. Accordingly, they tapped the bore-hole, and from that date the railway-station has been lit with natural gas. The consumption is about 1,000 cubic feet per day.

Hearing of this very practical outcome of the second discovery, the writer expected to hear also that extensive explorations would be made to ascertain the extent of the gas-bearing area in the neighbourhood. But finding that no further steps were taken, he communicated with some American friends, who were thoroughly conversant with the natural-gas industry of the United States of America. These gentlemen asked the writer to take steps in the matter at once.

The writer located positions for six exploratory bore-holes, boring was commenced, and in each and all of these bore-holes natural gas was found, at levels varying from 300 to 400 feet below the surface, the farthest bore-hole of the six being distant about 3,600 feet from the railway-station. These six bore-holes were started in the Hastings Sands which (in the Heathfield district) lie some 400 feet geologically above the Sub-Wealden boring, at Netherfield, which was started in the Purbeck Beds. The Hastings Sands are composed principally of sandstones and iron-bands, marls, etc., which make it a "cap" admirably adapted to, and indispensable for, acting as a natural holder for gaseous volumes.

FIG. 2.—NOS. 2 AND 3 BORE-HOLES IN THE VALLEY.

Heathfield is built on the well-known Mid-Sussex anticline. The Sub-Wealden boring, started in the Purbeck Beds, situated some 9 miles east, is on the same anticline, and this fact conclusively proves the relative identity of the two discoveries.

Many people have stated that it is impossible for gas to exist in Sussex, but they talk without the slightest knowledge of the geological structure of that country. The Purbeck is well known to have bituminous beds throughout its whole course, for example from Swife Farm, Pounceford, where the Purbeck is exposed between Heathfield and Netherfield, several tons of

bituminous shales have been distilled giving off paraffins, etc. The Kimeridge Clay, lying about 200 feet below the Purbeck Beds, has been proved to be the thickest bed of Kimeridge Clay in England, and 250 feet of it is known to be of a very bituminous nature. Again, the Oxford Clay, lying below the Kimeridge Clay, is also known to be bituminous.

In searching for natural gas in the United States, three points are mostly held in view:—(1) Have the rocks been disturbed? If so, no further time need be wasted looking for gas. (2) Is it an anticlinal formation? And (3) are there any known bituminous beds below?

FIG. 3.—No. 4 BORE-HOLE.

Holding these points in view the writer may say that:—(1) In this part of Sussex, the iron-formation of the Hastings Sands is practically not disturbed at all. (2) It is wellknown to geologists that the North and South Downs are simply the remnants of an enormous anticline. And (3) there are three successive bituminous beds proved to lie immediately under the sandstones.

Consequently, there is every probability of the existence of a large and lasting rich natural gas-field. It is well known that certain beds of the Kimeridge Clay have been burnt as fuel at Kimeridge. But the writer is sure that most of the gas in

Dorset must have escaped, owing to the absence there of the overlying capping beds of sandstone.

Lately, the writer has heard of gas being found at Bassingbourne, in Cambridgeshire, where also it is known that the Kimeridge Clay comes to the surface. A well, there, is affording a fair supply of natural gas.

Again, at King's Lynn, the writer understands that there has been talk recently of starting a distillery for the production of paraffin from the Kimeridge shales. This, he thinks, is further proof of the exceedingly bituminous nature of the Kimeridge Clay.

At Mayfield, about 5 miles from Heathfield, borings have been commenced in two positions on the Hastings Sands, and in one, gas has already been struck; while in the other, at a depth of 300 feet, a stratum, 20 feet thick, affords a fair yield of petroleum.

Borings are now being made over some 200 square miles in the county of Sussex, and the writer hopes soon to prove large supplies of gas throughout this territory. At Heathfield, between 70 and 80 houses are already being supplied with natural gas for lighting (using incandescent mantles), heating and cooking; and for lighting street-lamps. The gas is also being used in gas-engines. Facilities have, moreover, been afforded by the London, Brighton and South Coast Railway Company for the laying of conduit-pipes along their lines to supply the gas-works of the large towns in the vicinity.

Eastbourne lies about 16 miles to the southward of Heathfield. The gas-works, there, supply about 1,000,000 cubic feet per day, using a fairly good gas-coal, which yields say as high as 10,000 cubic feet to the ton. This means that over 100 tons of coal must be carbonized daily to supply Eastbourne with coal-gas. Nearly 40,000 tons of coal must annually be carried to Eastbourne from the coal-fields, to supply the inhabitants with gas for light, heat and power.

The Composition of Heathfield Natural Gas.—The Sussex natural gas in its natural state gives, in an ordinary Argand burner, a light of about 12 candlepower. Some people have gone so far as to say that the gas must be enriched on coming from the earth; but this lighting-power is not a unique feature of

natural gas, as some of the gas in America gives an equal light. The majority of the natural-gas fields of America, however, yield a gas which gives but a poor light in ordinary burners.

Prof. H. B. Dixon, who (the writer believes) analysed Heathfield gas for the Royal Coal Commission, has put on record figures which account for the high illuminant value which it has been proved to possess, as follows:—

	Per cent.
Methane	93·4
Ethane	3·0
Nitrogen	2·7
Carbon monoxide	0·9

FIG. 4.—BORE-HOLE AT MAYFIELD STATION.

It is the 3 per cent. of ethane, which gives Heathfield gas its conspicuous superiority, to most of the natural gas of America, as an illuminant.

The great point in the future of Heathfield gas will be its value as used to provide machine-power. The engines, in use at Heathfield, consume about 13 to 15 cubic feet of natural gas per horsepower as against 20 to 25 cubic feet of coal-gas. These figures are sufficient indication of the enormous saving that may be effected.

The heating power that can be obtained from a gas containing 93 per cent of methane need not be mentioned to anyone who has ever interested himself in gas-world matters; and natural gas of the Heathfield quality, easily stands in front of all other kinds of fuel.

In an estimate made last year, it transpired that in America 1,000,000 households and 4,000,000 people were furnished with this ideal fuel and light. There were over a hundred iron-works and steel-works using natural gas exclusively as fuel; and the cost of gas-fuel was under 12s. 6d. (3 dollars) per ton of sheet steel. In Pittsburg, the proprietors of a flint-glass works are saving 49 per cent. of their fuel-bill by using natural gas in place of coal.

The iron-works of the Wealden area employed some 5,000 men in 1760, when the coal in the North took iron-working away from the South of England. To-day, not an ounce of iron is smelted in all the Wealden territory; no glass is made, although the writer believes that glass-sand, so plentiful at Mayfield and elsewhere in the Weald, is sent to the North of England for making fine glass.

Now, if it can be proved that there is a huge gas-field lying under the whole of the Weald, then the industrial life of the South of England can be revolutionized. Iron is there, sand is there, and both can be worked with fuel on the spot. The fuel is the cheapest in the world, the cost of carriage will be obviated, and in addition to seeing the old industries revived an enormous tract of country, at present devoted solely to agriculture, will be opened up for new industries.

The writer heard recently that the London, Brighton and South Coast Railway Company are thinking of working part of their railway on the electric-traction system. As this railway passes over about 40 miles of what the writer is confident is gas-bearing land, there will be no difficulty in obtaining power for the production of their current.

In Belgium a gas-engine of 3,000 horsepower is now at work; and, in America, gas-engines of 1,500 brake-horsepower have been working with natural gas.

The pressure of the gas at Heathfield varies from 134 to 200 pounds per square inch.

As to the permanency of the gas, the writer may mention

that in China natural gas (from identically similar geological formations) has been used for evaporating salt, for over 1,000 years. The Chinese gas-fields lie on the frontier of Tsetchuan.

Natural gas is used to great economic advantage in Medjansk, Russia, and is employed for municipal lighting in two villages on the Zuyder Zee in Holland. The gas in all these cases is derived from precisely the same strata.

The writer feels certain that an ample supply of gas will be found, at great pressure, and of undoubted permanency.

FIG. 5.—No. 6 BORE-HOLE.

There are some 11,000 gas-wells in the United States, there are at present 9 in Sussex, 10 others are in course of sinking, and there is sufficient gas-bearing land to warrant the sinking of many thousands of wells.

A comparison of the heating power of gaseous fuels per 1,000 cubic feet at 40° Fahr. and at atmospheric pressure, is approximately as follows:—

	British thermal units of heat.
Sussex natural gas	1,100,000
Coal-gas	735,000
Water-gas	322,000
Producer-gas, heated	156,000

The volumes of gases used to produce 1 horsepower in any wellknown make of gas-engine are as follows:—

	Cubic feet.
Sussex natural gas	12 to 15
Coal-gas	20 to 25
Water-gas	60 to 80
Producer-gas	100 to 120

Mr. J. J. H. Teall (Director of the Geological Survey of the United Kingdom) wrote that the existence of a natural gas-field which might ultimately prove to be of considerable economic importance and was, in any case, of great scientific interest had been clearly established in the area in question. Up to the present, the exploration had been confined to the central part of the dome; but it would be interesting to know whether a similar yield of gas would be obtained from bore-holes put down on the prolongation of the Wealden anticline to the west of Heathfield, where a greater thickness of overlying strata, some of which might act as reservoirs, would have to be pierced.

Mr. B. H. Thwaite (London) wrote that several years ago he gave serious study to the phenomena of the origin of natural gas; and in that investigation, he received great assistance from the late Mr. Weeks of Pittsburg, U.S.A. As a result of his investigations he came to the conclusion that natural gas was the product of the agents that produced petroleum; and that the origin of petroleum was due to marine, organic, animal and vegetable matter that by geological disturbance had been subjected to physical and especially thermal influences, resulting in the eventual formation of the liquid and gaseous hydrocarbons, known respectively as petroleum and natural gas. It was remarkable and it might be offered as correlative evidence as to the marine origin of the two hydrocarbon-agents, that the great natural-gas and petroleum-areas in the United States, the Causcasus, and in China were almost identical with the salt-deposit areas. It was this geological fact, and the resemblance of the geological and anticlinal formation of the oil and natural gas-fields of the United States with those of the salt-areas of Cheshire that led him to suggest that the Bradford drillers of

Pennsylvania should be asked to drill down to a depth of 3,000 feet through the Cheshire strata, to determine whether natural gas or oil existed below the salt-deposits of Cheshire. As a result of several interviews, Sir Joseph Verdin accepted these suggestions on behalf of the Salt Union, but unfortunately that company did not employ American skilled oil and gas-well drillers, and the result was such as might have been expected: the drills were lost at a depth of 1,000 feet, and the project was abandoned. He was still of opinion that the salt-areas of Cheshire should be drilled through, and that the Government might do this service for the country. This suggestion he respectfully commended to the Royal Commission on Coal-supplies.

Referring to Mr. Pearson's paper, he noticed that there was a striking difference between the character of the gas exuded from the bore-holes of Heathfield and that of the United States. The natural gas of the United States might be said to be represented by the following volumetric analysis:—Methane, 60 to 85 per cent.; hydrogen, 15 to 25 per cent.; and ethyl hydride, 5 to 10 per cent.

The natural-gas strata in Pennsylvania were struck at a depth of about 1,600 feet below the surface, and the gas issued from bore-holes, 5 inches in diameter, at very high and sustained pressures. The expansion of the gas by the wellknown thermodynamic law produced a considerable freezing effect. The gas was distributed over very many miles, but even then special automatic reducing-valves had to be employed. Unfortunately, the data that would enable a calculation to be made to determine the extent and durability of the natural-gas supply over a specific area were absent from Mr. Pearson's paper.

The flow of gas from a bore-hole (4 inches in diameter) determined for a period of 6 months, which determination would give the precise figures of the fall of pressure, and include analyses of the gas taken at different periods, would finally settle the question of the volume of gas in the Sussex gas-field. The Sussex gas, if Mr. Pearson's figures were representative, was too rich in hydrocarbons to be satisfactorily employed in engines of large cylinder-capacity. Of course, the gas was available for comparatively small power-engines, just as with town-gas. If the Sussex gas were not of "petroleum origin," it was doubtful whether the supply was as extensive as one would desire.

From the extremely interesting evidence submitted by Mr. Pearson, he thought that they were justified in saying that it was a case for the Government to determine whether they had not in the new fields a new potential of fuel-supply that would add to the coal-asset, which enterprise had discovered near Dover.

Mr. F. H. OLIPHANT (United States Geological Survey) wrote that in his report drawn up for the United States Government for 1902, he had given a history of the original introduction of natural gas in the United States and a list of the strata in which it was found.* He might say, in a general way, that in that country no large and permanent supply of natural gas was found in strata higher than the Upper Carboniferous measures. Some natural gas was found in the newer formations, from the Cretaceous to the Upper Eocene, and in Texas in measures that were even newer than the last named. Texas, Louisiana and California possessed deposits of natural gas in the newer formations, but they lacked the area and persistence of the Appalachian and Lima fields. A series of open porous strata covered by a shale folded in gentle anticlinals, persistent over large areas, had been found to contain the largest reservoirs, and these conditions were universal over the great areas of natural-gas territory in the Appalachian field in New York, Pennsylvania, West Virginia, Ohio, Indiana and Kentucky. Some 18 to 20 years ago, large areas of natural gas were developed in the great broad swell, of what was known as the Cincinnati anticlinal, in northwestern Ohio and eastern and central Indiana, where the Trenton Limestone of the Lower Silurian formation was of an open character. Capped by the Utica and Hudson-river Shale, large areas of gas were found under similar structural conditions to those of the Appalachian field. The supply in the Lima (Indiana) field had been greatly depleted, although Indiana still produced much natural gas. West Virginia contained the largest-known areas of high-pressure gas. However, outside of the fields reaching in the geological scale from the Lower Silurian up to the Carboniferous on the north-western flank of the Appalachian mountains in the United States, less than 1 per cent. was produced from the newer geological horizons in 1902. The value

* "The Production of Natural Gas in 1902," *Mineral Resources of the United States, Calendar Year 1902*, pages .

of all the natural gas produced in the United States was £6,430,764 (30,867,668 dollars), and in quantity it amounted to not less than 205,784,453,333 cubic feet, equal to 10,289,000 short tons of coal.

The depth of gas-wells in the United States ranged from 1,000 to 3,000 feet, the average being about 1,800 feet.

Natural gas had been found in the newer rocks furnishing petroleum, in Rumania, Galicia, Russia, India, China and Japan, but nothing that would compare with the output of the United States.

Dr. I. C. White (State Geologist, West Virginia Geological Survey) wrote that the conclusions of Mr. Pearson concerning the possibility of the existence of vast supplies of natural gas in the south-east of England appeared to be very well sustained. The perusal of his paper left no room for doubt that the same geological conditions obtained in the Sussex region as those that were found in the United States, wherever natural gas and petroleum occurred in commercial quantities: namely an anticlinal, monoclinal or relief structure of sedimentary beds by which porous strata had been slightly disturbed and tilted into gently-dipping (30 to 300 feet per mile) beds. Given these conditions, natural gas might be looked for in commercial quantity in America at any horizon of the sedimentary beds from the Archæan to Recent. Large volumes of gas had been found in the basal members of the Potsdam Sandstone in New York State, only a few feet above the primitive granite; while much of the oil and gas of California occurred in the latest Pleistocene sands and gravels. Where the cover was good, such as the plastic and putty-like clays of the Pleistocene and more recent beds, the rock-disturbance might be very great, and the strata dip away from dome-shaped up-lifts at very high angles, as at Beaumont (Texas), many localities in California, also at Grosny and other Russian fields, where petroleum and gas were found in unlithified beds, or at least where the overlying deposits were clays, marls and sands, instead of shales, limestones and sandstones. High dips in the Carboniferous, Devonian or Silurian strata, in America, at least, were always sufficient evidence that no commercial quantities of oil or gas could be found therein, since the profound fissuring of the beds due to great disturb-

ance, had permitted the escape of all the volatile hydrocarbons, which would otherwise have been imprisoned. Consequently, Mr. Pearson's statement about "rock-disturbance" as a factor in the search for gas needed the qualifications just given, namely, a certain amount of it was essential in all cases, and in unlithified beds it might be very great, but in consolidated sediments the disturbance must be gentle.*

Mr. W. WHITAKER (Croydon) wrote that Mr. Pearson had neglected to mention a most important paper, on the subject, written by Mr. Charles Dawson. The absence of any notice of this and of other later papers somewhat depreciated the value of Mr. Pearson's paper, and gave it the appearance of a first notice, which it was not. Mr. Dawson had given detailed sections of some of the wells and analyses of the gas. It was a pity that details of the later bore-holes were not attached to Mr. Pearson's paper.

The following papers have been written upon this subject:—

Dawson, Charles, "Natural Gas in Sussex," *Transactions of the South-eastern Union of Scientific Societies*, 1898, pages 73-80; *Natural Science*, 1898, vol. xiii., pages 109-114; and *Science Gossip*, 1898, vol. v., pages 45-47.

—, "Discovery of a large Supply of 'Natural Gas' at Waldron, Sussex," *Nature*, 1897, vol. lvii., pages 150-151.

—, "The Discovery of Natural Gas in East Sussex," *Quarterly Journal of the Geological Society of London*, 1898, vol. liv., pages 564-571.

—, "Excursion to Heathfield and Brightling," *Proceedings of the Geologists' Association*, 1901, vol. xvii., pages 171-175.

Hewitt, Dr. J. T., "Note on Natural Gas at Heathfield Station, Sussex," *Quarterly Journal of the Geological Society of London*, 1898, vol. liv., pages 572-573.

Whitaker, W., and Clement Reid, *Memoirs of the Geological Survey of England and Wales: The Water-supply of Sussex from Underground Sources*, 1899, pages 65-70 and 87-89.

Woodward, H. B., "Notes on the Occurrence of Natural Gas at Heathfield, Sussex," *Memoirs of the Geological Survey: Summary of Progress of the Geological Survey of the United Kingdom for 1902*, pages 195-199; and *Trans. Inst. M.E.*, 1903, vol. xxv., pages 717-723.

Anon., "Natural Gas in Sussex," *Natural Science*, 1898, vol. xiii., page 303.

—, "Petroleum in Sussex," *Standard*, May 3rd, 1898, page 8.

—, "Natural Gas in Sussex," *The Times*, September 10th, 1902, page 5; and *Journal of the Society of Arts*, 1902, vol. l., pages 824-825.

* A full discussion of the factors involved in the accumulation of oil-and-gas deposits is contained in vol. i. of the *Reports of the West Virginia Geological Survey*, 1899, pages 123-378.

The PRESIDENT (Mr. J. C. Cadman) proposed a vote of thanks to Mr. Pearson for his interesting paper.

Mr. H. C. PEAKE seconded the resolution, which was cordially approved.

DISCUSSION OF DR. J. S. HALDANE'S PAPER ON "MINERS' ANÆMIA, OR ANKYLOSTOMIASIS."*

Dr. J. LIVINGSTONE LOUDON (Medical Officer of Health of Hamilton, N.B.) wrote that Dr. J. S. Haldane's paper was extremely interesting, and was moreover, he considered, an extremely full and accurate treatise on the disease. A few weeks ago (July 25th, 1903) he wrote to the local authority, in Hamilton, an admonitory memorandum on the same subject. In that memorandum he directed their attention to the possibility of the disease invading the coal-pits there, and instanced two likely methods by which it might come:—(1) Reservists, who came home to work in the pits after serving their time abroad in districts where ankylostomiasis was common; and (2) Polish workmen, who came from districts known to be badly affected. There were now many hundreds of these Poles working in Lanarkshire pits.

In the *British Medical Journal*,† a case of ankylostomiasis was reported by Prof. Ralph Stockman, Glasgow University, the workman affected being a collier from a Lanarkshire coal-pit. He noticed that, at the discussion on ankylostomiasis at the International Congress of Hygiene, it was pointed out that the number of cases was on the increase on the Continent—the numbers being in 1896, 107; in 1900, 275; in 1901, 1,130; and in 1902, 1,355. There was no mistaking the meaning of these figures, and it was added that the Bacteriological Institute examined the fæces of 10,000 miners and discovered the ova of *Ankylostomum duodenale* in 55 per cent.

Dr. Haldane's description of the symptoms was most useful, and he also drew attention to one most important point regarding the anæmia found, when he stated that although the corpuscles were diminished in number, as well as the hæmoglobin

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 643.

† 1903, vol. ii., page 189.

in quantity, still, "the diminution in the proportion of corpuscles is not so great as in the proportion of the hæmoglobin.*

Dr. Haldane's paper would do much to prevent the invasion by the disease of British mines, and also to check its increase where it had already obtained a footing, as the facts mentioned in his paper were bound to come under the notice of the great majority of colliery-managers, and the hygiene of a colliery was to a large extent under the control of the manager. It would be well, however, that the workmen themselves should receive plain and readily-understood teaching regarding this disease; and possibly this could best be done by a pamphlet or printed notice, short and couched in simple language. As regarded fulness and scientific accuracy, Dr. Haldane's paper left nothing to be desired. He noticed in the *Lancet*† that the Sanitary Committee of the Glamorganshire County Council had instructed its medical officer of health (Dr. Williams) to prepare handbills in both English and Welsh describing the symptoms of ankylostomiasis, and how the disease might best be guarded against. A circular was also to be sent to medical men, informing them that the examination of material from suspected cases would be undertaken at the county laboratory. It would, he thought, be well that other local authorities should take precautions on similar lines.

Dr. J. COURT (Staveley, Chesterfield) wrote that Dr. Haldane's paper, on the subject of miners' anæmia in all its bearings, was so complete and up-to-date in every detail, that he could really add nothing to the information contained in it, or to the advice that the author gave in dealing with a possible outbreak in the collieries of this country. Besides the epidemic in Cornwall, one case of miners' anæmia had been reported in Glasgow, where a soldier from India, who no doubt brought the complaint with him, was admitted into the Infirmary there, last May, and sent out cured.

This man had been working in one of the Lanarkshire collieries, and, as there were thousands of Poles and other foreigners employed in the mines of Scotland, the members could quite understand how vital it was, for the health and welfare of the men and also for the regular working of the

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 649.

† 1903, vol. ii., page 774.

mines, that the utmost vigilance should be exercised in detecting any infected persons and preventing them from going into the pits. He (Dr. Court) would therefore suggest that, in future, no foreigner, nor any British subject, nor any other individual, who had lived in tropical countries or worked in foreign mines, should be employed in a colliery in Great Britain, unless he could prove that he was absolutely free from the eggs and larvæ of the *Ankylostoma*-parasite.

Dr. J. S. Haldane wrote, with regard to the Polish miners referred to by Dr. Loudon, that he believed that only those Poles who had previously worked in Continental mines were at all likely to carry the infection. Ankylostomiasis was known to exist among the general agricultural population in Italy and Hungary, but it had not, so far as was known, extended farther north, except among miners, and occasionally among brick-makers. Many thousands of Poles were employed in the infected collieries of Westphalia, but he was not aware whether any of the Poles in Scotland had previously worked in Westphalian or other Continental mines.

DISCUSSION OF MR. W. DENHAM VERSCHOYLE'S PAPER ON "THE SMELTERS OF BRITISH COLUMBIA."*

Mr. William F. Robertson (Provincial Mineralogist of British Columbia) wrote that Mr. Verschoyle's figures were presumably taken from his Official Report to the Minister of Mines and were, he believed, as nearly correct as possible. Mr. Verschoyle's paper gave a very comprehensive and concise review of the smelters of the province, but to bring the paper up to date more nearly he might state that:—(7) The North-west Smelting Company's smelter at Crofton was completed in the early part of 1902. (8) The Tyee smelter at Ladysmith was completed, and running in December, 1902. Views of both of these smelters and plans of the latter were contained in his Report for 1902.† He might say that both of these smelters had

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 678.

† *Annual Report of the Minister of Mines for the Year ending 31st December, 1902, being an Account of Mining Operations for Gold, Coal, etc., in the Province of British Columbia.*

been in successful operation and were so now, operating on copper-ore carrying from 25 to 30 per cent. of barium sulphate, and 5 to 10 per cent. of zinc, making a rather unique smelting problem. Both of these smelters took in such custom-ores as might be offered.

Another large smelter had been erected at Boundary Falls, a few miles south of Greenwood, with a capacity of 300 to 500 tons per day. It was owned by the Montreal and Boston Copper Company and had been in operation on the ore from their mines situated near those (4) of the British Columbia Copper Company and of a similar character.

A lead-smelter, one large stack, was started last year and almost completed at Marysville, near Cranbrook, East Kootenay, but for financial reasons was not finished then, although it probably would be completed this year. He might also mention that the Northport smelter, although situated in the State of Washington, was entirely owned by the Le Roi Mining Company of Rossland, British Columbia (but was placed there on account of conditions which no longer exist) and was now being run on British Columbia coke supplied by the Crow's Nest Pass Coal Company.

Mr. W. Denham Verschoyle wrote that he looked upon the official report of the Minister of Mines for British Columbia as the most reliable source of information, and it was therefore, quoted largely in his paper; but a considerable volume of the information contained in his paper was obtained from the smelters and from other sources. It was one of the most satisfactory indications, and was illustrative of the progress being made in the smelting-industry of British Columbia, that a paper such as he had endeavoured to compile should require to be rewritten annually in order to keep pace with the advancement which was actually taking place.

Mr. Maurice Deacon read the following "Notes on Glapwell Colliery":-

NOTES ON GLAPWELL COLLIERY.

By M. DEACON, M.Inst.C.E.

Introduction.

Glapwell colliery, the property of the Sheepbridge Coal and Iron Company, Limited, is situate in the county of Derby, about 10 miles from the western edge of the Derbyshire and Nottinghamshire coal-field.

Shafts.—There are two shafts, 14 feet in diameter, sunk twenty years ago to the Top Hard seam, which lies at a depth of approximately 900 feet from the surface at this point. Both shafts are lined with cast-iron tubbing for a depth of 270 feet, and the pressure of water on the bottom wedging-curb is 142 pounds per square inch.

Surface-plant.

The general arrangement of the surface-plant is shown in Fig. 1 (Plate XVIII.).

Winding-engines.—At the No. 1 or downcast shaft, the horizontal high-pressure winding-engine, with two cylinders, 36 inches in diameter and 72 inches stroke, has a parallel drum, 16 feet in diameter. The winding-ropes are 1½ inches in diameter, of plough-steel, galvanized. The cages are double-decked, each deck carrying two tubs, and each containing an average of about 10 cwts. of coal. There are eight wire-guides, 1½ inches in diameter, upon each of which is suspended 50 cwts. of weights. There are also two rubber-guides, suspended between the cages, to obviate the possibility of a collision. The time occupied in winding is 25 to 30 seconds, in changing 5 to 10 seconds, and in practice 240 tons an hour is drawn when there are no delays. Haniel and Lueg keps are in use, by which a saving of 2 seconds per draw has been effected, and this is equivalent to an increased output of 120 tons per day. The cages are decked simultaneously at the top and bottom of the pit. The steam-consumption is about 45 pounds per indicated horsepower.

At the No. 2 or upcast shaft, the horizontal high-pressure winding-engine, with two cylinders, 30 inches in diameter by 66 inches stroke, has a slightly conical drum, ranging from 12 to 14 feet in diameter. The engine is only used for coal-winding when the No. 1 pit winding-arrangements are out of order.

TABLE I.—COMPARATIVE TESTS OF TWO QUALITIES OF FUEL ON THE SAME BOILERS.

No. of experiment	1	2	3	4	5
Description of furnace	Ordinary fire-bars.		Caddy fire-bars.		Pillatt-Furnace *
Size of boiler: length, feet	28	28	28	28	28
Do., diameter, ,,	8	8	8	7	7
Fuel	Slack †	Smitham ‡	Slack †	Smitham ‡	Smitham †
Date	1901 Apl. 15th	1902 Dec. 11th	Average of 5 trials	1903 June 18th, steam-jet used and deducted	Average of 5 trials; steam-jets used and deducted
Duration of test	10 a.m. to 4 p.m.	10 a.m. to 4 p.m.	10 a.m. to 4 p.m.	10 a.m. to 4 p.m.	10 a.m. to 4 p.m.
Direction of wind	S.W.	E.	—	N.E.	—
Coal consumed, pounds	5,742	3,402	4,881	3,042	3,731
Ashes taken out ,,	1,118	771	570	336	536
Do. per cent.	19·0J	22·66	11·86	11·01	14·18
Fire-grate area, square feet	38	35	38	38¼	33
Water evaporated:					
Total quantity, gallons	3,154	2,242	3,321	1,938	2,477
Per hour	525·6	373·6	553 5	323§	412
Temperature of feed-water, degrees Fahr.	58	44	63	58¼	4?¼
Apparent duty, pounds	5·49	6·59	6·76	6·36	6·64
Duty corrected to temperature of 212 Fahr., pounds	6·53	7·90	8·01	7·56	7·96
Cost of fuel, per ton	4s.	2s.	4s	2s.	2s.
Cost of evaporating 1,000 gallons	3s. 2·95d.	1s. 4·25d.	2s. 7·30d.	1s. 4·79d.	1s. 4·13d.
Steam-pressure per square inch, pounds	60	64·66	62	68·5	60·48
Quantity of air passing through furnace per minute, cubic feet	2,023	2,945	2,523	3,010	1,005
Temperature of inlet-air, degrees Fahr.	...	62	85	54	59¼
Temperature of waste-gases at back-end of boiler, at junction with main flue, degrees Fahr.	...	940	...	—	692¼
Temperature of waste-gases at chimney-bottom, degrees Fahr.	...	560	—	—	—
Temperature of waste-gases at chimney-top, degrees Fahr.	—	380	...	—	—
Weight of coal consumed per minute, pounds	12·84	9·45	12·99	8·45	10·26
Flutometer readings, millimetres	12	13¼	11·4	14	13¼
Do. inches	0·48	0·53	0·45	0·55	0·53
Water gauge on chimney	1·20	—	—	—	—
Calorific power of ordinary slack used	14·4	12·9	14·4	12·9	12·9
Duty of coal per cent.	45·30	61·24	55·39	59·00	61·70
Increase in duty due to use of Caddy fire-bars over ordinary fire-bars per cent.	—	—	22·62	—	—
Consumption of steam by steam-jets per cent.	—	—	—	4·33	—

* Fitted with four steam-jets.
† Through meshes, 1 inch square.
‡ Through meshes, ½ inch square.
§ Steam-jet used 309 gallons.

Boilers.—There are 15 Lancashire boilers, 12 are 28 feet long by 7 feet in diameter, working at a maximum pressure of 70 pounds per square inch; 2 are 28 feet long by 8 feet in diameter; and 1 is 30 feet long by 8 feet in diameter, each working at a maximum pressure of 100 pounds per square inch. The boilers working at pressures of 70 and 100 pounds are connected by a surplus-steam valve, set to blow off at 98 pounds per square inch; and, as an additional precaution, a safety-valve is fixed on the low-pressure side of the surplus-steam valve.

Several types of automatic stokers have been tried, from time to time, experimentally, but none have been adopted. Five of the boilers are now fitted with Caddy hollow fire-bars, and three with Pillatt hollow fire-bars, both of which are giving satisfactory results. Table I. contains the results of comparative tests made with two qualities of fuel on the same boilers, and the figures are the average results of several tests taken over a period of six months. The tests clearly indicate, both by practical results (Table I.) and the analysis of the flue-gases (Table II.) the advantages to be gained by the introduction of fresh air to the back of the furnace.

TABLE II.—ANALYSES OF FLUE-GASES.

No. of experiment ...	1	3
Fuel	Slack.	Slack.
Description of furnace ...	Ordinary fire-bars.	Caddy hollow fire-bars.
	Volumes.	Volumes.
Carbon dioxide (CO_2) ...	14·2	14·0
Carbon monoxide (CO) ..	34·0	2·5
Oxygen (O_2)	2·4	6·2
Nitrogen (N_2)	49·4	76·1

Hotchkiss cleaners are attached to four of the boilers, and have been in use for two years. The average weight of dirt removed from each boiler during this period is 3,824 pounds.

The boiler-water is very hard, and forms a heavy scale in the dry season, when surface-water is scarce.

The fuel used consists largely of inferior coal dressed out on the picking-belts. Tests made at various times indicate that 11½ per cent. of ash is removed from the boilers.

Tests upon radiation and waste indicate a loss of nearly 14 per cent. of the fuel used.

The approximate accuracy of these experiments was tested for the year 1902 as follows:—

	Tons.	Tons.
Coal used at boilers during 1902 (actual weights) ..		29,494
Deduct:—		
Ash, 11½ per cent.	3,391	
Radiation and waste, 13·92 per cent. ...	3,633	
		7,024
		22,470
Coal consumed as calculated from indicator-diagrams ...		23,213
Difference		743

The total colliery-consumption is about 5½ per cent. of the coal raised. This somewhat high figure is due largely to the steepness of the mine and the length of haulage-roads, which will be hereafter referred to under that head.

Hauling-engines.—There are three endless-rope hauling-engines, all placed upon the surface. Their dimensions are as follows:—Old engine-plane engine, one cylinder, 26 inches in diameter by 36 inches stroke, geared 7½ to 1; new engine-plane engine, one cylinder, 26 inches in diameter by 36 inches stroke, geared 10 to 1; and Hardwick engine, two cylinders, 16 inches in diameter by 36 inches stroke, geared 9 to 1. In each case, the ropes are taken down the upcast shaft, and work, without intermediate gearing, at speeds of about 3, 2 and 1½ miles an hour respectively.

Air-compressor.—The air-compressor has two steam-cylinders, each 30 inches in diameter, and two air-cylinders, each 30 inches in diameter, by 60 inches stroke. It is now superseded by electric plant.

Electric Plant.—The compound condensing slow-speed Robey engine has a high-pressure cylinder 19 inches in diameter, and a low-pressure cylinder 30 inches in diameter by 40 inches stroke; and runs at 90 revolutions per minute. It drives a Westinghouse three-phase ten-pole generator, giving 225 kilowatts at 440 volts and 30 cycles, when running at 360 revolutions per minute. The exciter produces 5·62 kilowatts at 125 volts, at 850 revolutions per minute. This generator supplies current to three motors of 50 horsepower, one of 30 horsepower and five of 7½ horsepower, at various points in the pit and on the surface (Fig. 10, Plate XIX.).

A compound high-speed engine, with a high-pressure cylinder 9 inches in diameter, and a low-pressure cylinder 13½ inches in diameter by 7 inches stroke, runs at 268 revolutions per minute. It drives a Westinghouse three-phase four-pole generator, giving 20 kilowatts at 440 volts and 30 cycles, when running at 900 revolutions per minute. This plant is used principally for lighting, but it is sometimes used for pumping when the large set is not required for hauling.

The Robey engine is very economical, consuming about 15 pounds of steam per indicated horsepower, at a vacuum of only 10 pounds.

Waddle Fan.—Duplicate single high-pressure horizontal engines, with cylinders 30 inches in diameter by 36 inches stroke, are coupled direct to the shaft of a Waddle fan and run at 50 revolutions per minute. The fan is 40 feet in diameter, and is preserved as a stand-by.

Capell Fan.—A compound condensing slow-speed engine, with a high-pressure cylinder 16 inches in diameter, and a low-pressure cylinder 28 inches in diameter by 36 inches stroke, runs at 84 revolutions per minute. The Capell fan, 12½ feet in diameter by 8½ feet in width, is rope-driven, geared 3·11 to 1. The engine is economical, using about 14 pounds of steam per indicated horsepower when condensing. This fan was put down as a duplicate, and a more efficient and economical fan.

The two fans are working on the same mine and under similar conditions, with the exception of the drift, and this enables a useful comparison to be made between the relative efficiencies. Table III. contains the results of separate and independent tests made upon each fan.

Condenser.—A Wheeler surface-condenser condenses the exhaust-steam from the electric and fan-engines, and the old and new engine-plane hauling-engines. When not overloaded, a vacuum of 13 pounds per square inch is obtained. The condenser has a capacity of 20,000 pounds of steam per hour; but frequently more steam is passed through it, at the expense of the vacuum. The condensing water is cooled in ponds, having a superficial area of 26,028 feet and an average content of 182,000 cubic feet. This gives about 26½ square feet and 185 cubic feet per indicated horsepower, somewhat below the ascertained best practice of 39 square feet and 214 cubic feet respectively. Cooling-troughs, 600 feet long and 4 feet wide, with falls at intervals, are used to assist the cooling-ponds, and a weir is constructed between the upper and lower ponds.

The condensed steam is mixed with the feed-water, and greatly improves its quality.

TABLE III.—COMPARATIVE TESTS OF THE WADDLE AND CAPELL FANS WORKING UPON THE SAME MINE.

Description of fan	Waddle	Capell
Date of test	June 18th, 1899	January 28th, 1903
Diameter ... feet	40	12½
Width at centre ... feet	3 7/12	8½
Periphery ... feet	13 1/6	8½
Engine	Direct-coupled	Rope-gearing. 3·11 to 1.
Speed of engine—revolutions per minute	51·10	62·00
Speed of fan—revolutions per minute	51·10	192·82
Steam-pressure per square inch on engine-house gauge pounds	60	80
Average vacuum ... inches	–	19
Water-gauge, in fan-drift, placed at right angles to the current and covered with cotton-wool inches	2·20	2·78
Barometer in fan-drift ... inches	29·36	28·73
Thermometer in fan-drift—degrees Fahr.	62	59
Length of fan-drift ... feet	47	103
Area of fan-drift ... square feet	63	116·66
Number of revolutions of anemometer per minute	2,342	1,550
Quantity of air per minute, cubic feet	147,570	180,823
Horsepower in air	51·15	79·21
Mean steam-pressure, per square inch :		
High-pressure cylinder—pounds	16·8	26·75
Low-pressure cylinder— pounds	—	9·20
Horsepower :		
High-pressure cylinder	—	59·31
Low-pressure cylinder	—	63·12
Air-pump	—	6·00
Total	110·33	128·43
Efficiency ... per cent.	46·36	61·67
Capacity of fan ... cubic feet	3,140	1,053
Volumetric efficiency per cent.	91·94	89·83
Manometric efficiency	0·42	0·38
Theoretical water-gauge .. inches	5·24	7·28
Periphery-speed of fan per second feet	107·07	126·2
Total steam consumed per hour, calculated from diagrams—pounds	3,506	1,133
Steam used per hour in steam-jackets ... pounds	—	234
Steam used per horsepower per hour ... pounds	31·77	11·71
Volume of air per revolution of the fan ... cubic feet	2,887	937
Cost of fuel (at 3s. per ton) per indicated horsepower	£3 6s. 8·94d.	£1 3s. 7·67d.
Cost of fuel (at 3s. per ton) per horsepower in the air	£7 3s. 11·62d.	£1 18s. 3·93d.
Cost of fuel (at 3s. per ton) per annum for 1,000 cubic feet of air per minute	£2 10s. 1d.	£0 16s. 10d.
Fuel used (at 3s. per ton) per annum for 147,000 cubic feet of air per minute ... tons	2,458	548
Do. ... cost	£378	£82

The incrustation in the tubes caused by the impure water is treated periodically (about every four months) with a solution containing 25 per cent. of hydrochloric acid, and this effectually cleans the tubes.

Pit-bank.—The No. 1 pit headstocks are of the latticed-steel girder type, 68 feet high to the centre of the pulleys. The No. 2 pit headstocks are built of pitchpine.

The No. 1 pit-bank is automatically worked by means of creepers and gravitation. The full tubs are crept upward from the bottom-deck to the top-deck level, and after being tipped, the empty tubs gravitate to a self-acting drop-cage, which delivers them to the bottom-deck level, whence they gravitate to the pit-top. The empty tubs for the top-deck are crept upward to a sufficient height, to enable them to gravitate to the empty side, whence they are switch-backed to the pit-top.

Belts and Screens.—The tipplers are of the ordinary side-tipping type. The coal is delivered upon a cross delivery-belt, where the best brights are picked out, the remainder being delivered over a bar-screen, with 4½ inches spaces, through which the steam-hards, cobbles, nuts and slack pass to a jigger—the nuts and slack pass through a bar-screen with 1¼ inches spaces, and the steam-hards and cobbles pass over the bars to a belt, 200 feet long and 4 feet wide, on which they are picked. The nuts, slack and smitham are elevated by a short conveying-belt to another jigger, where they are separated into their respective sizes. At the delivery end of the belt is a short bar-screen, which separates the cobbles from the steam-coal, the former being conveyed by a cross-belt to the cobble-wagons. The large coal passes over the jigger-bars to another belt running parallel to, and of the same length and width as, the steam-coal belt, upon which the cannel is separated and all impurities removed. The large coal then passes into the wagons at the end of the belt, and is sold for blast-furnace or locomotive purposes.

Shops.—All important repairs are made at the Sheepbridge iron-works, where there are extensive shops; and, therefore, only small shops are required at the colliery.

Underground.

Pit-bottom.—The porches are brick-arched, the top-deck is 14 feet wide by 15½ feet high, and the bottom-deck is 14 feet wide and 7½ feet high. The decking of the cages is done simultaneously.

Stables.—The stables are brick-arched, contain standings for 55 horses, and are lighted by electricity. The overall dimensions are 255 feet long, 19 feet wide, 6½ feet high in the standings, 6 feet high in the road along the bottom of the standings, and 8 feet high in the road in front of the mangers. All food is placed in the mangers, without passing the horses in the stalls.

Dip of Seam.—The dip of the Top Hard seam, which is nearly due east, is 1 in 5 near the pit, but it gradually decreases to 1 in 12 at a distance of 1½ miles in-bye.

Section of Seam.—The thickness of the Top Hard seam varies from 5 feet 11 inches to 6 feet 2 inches, and consists of alternate layers of bright, soft, hard, and mixed hard and soft coal (Table IV., and Figs. 2 and 3, Plate XVIII.). The brights are suitable for household use and for gas-making, while the hard coal is an excellent blast-furnace and locomotive coal. The steam-hards are sold for shipment and for use in iron and steel-works. The cobbles and nuts are excellent coals for use in gas-producers.

Table IV.—Sections of Top Hard Coal-seam.

North Side.	Ft.	Ins.	Ft.	Ins.
Bat	0	1		
			0	1
COAL, Top Brights ...	0	11		
COAL, Hards	0	8		
COAL, Softs	0	4		
COAL, Hards	2	4		
COAL, Brights	0	4		
			4	7*
Bat	0	1		
Jacks	0	3		
Bat	0	2		
COAL, Brights	0	9		
			1	3
			5	11

South Side.	Ft	Ins.	Ft.	Ins.
Bat	0	2		
			0	2
COAL, Top Brights ...	0	10		
COAL, Hards	0	9		
COAL, Cannel	1	5		
COAL, Hards	1	7		
COAL, Bottom Brights	1	5		
			6	0*
			6	2

* This coal is sent to bank.

On the southern side of the pit, a bed of cannel appears in the seam, and gradually thickens in a southerly direction, but it disappears on the northern side of the pit.

Workings.—Fig. 9 (Plate XIX.) indicates that practically the whole of the workings lie to the dip of the pits. The distance of the face of the No. 4 slant from the shaft is 1¾ miles, and it is 664 feet below the level of the pit-bottom.

The method of working is longwall. Levels or slants are opened (right and left) from the main engine-planes, and the coal is worked from these roads to the rise by means of stalls, 132 feet wide. The gate-road pack-walls are built 9 feet wide, and the goaf pack-walls, built at intervals of 15 or 18 feet, are 6 feet wide.

The roof is usually a fairly strong stone-bind, which settles gently upon the pack-walls, and breaks in the goaf. A portion of the pit has a rock-roof, which is liable to "weight" heavily.

The coal is worked on "end," except in the leading levels. The holing is made in the "jacks" underlying the main seam.

Haulage.—The main haulage, which is all of the endless-rope type, is actuated by the three hauling-engines already described (Fig. 9, Plate XIX.).

The old engine-plane ropes work from the junction of No. 4 slant to the pit-bottom, and haul all the coal from the main dip, No. 4 slant and the No. 3 south engine-planes. The new engine-plane ropes work from the far end of the No. 3 slant to the pit-bottom, and haul all the coal from that district, the north level and the No. 1 slant. The Hardwick engine-plane ropes haul all the coal from the far end of the Hardwick district to the pit-bottom.

In the old and new engine-planes overhead ropes are in use, the roads being double. The ropes rest upon the tops of the tubs, which are attached in couples to the rope by means of chains.

In the north, south and Hardwick districts, the ropes are carried underneath the tubs, which are run in sets of 6 full tubs and 24 empty tubs, by means of screw-clips.

Electric Haulage.—The new and old engine-plane haulages having reached the limit of their power, auxiliary electric haulage

has been adopted, and has been in use for about 12 months. Fig. 10 (Plate XIX.) shows the distribution of the electric cables in the underground roadways. The generating-plant has already been described.

The current is carried down the No. 1 or downcast shaft (Fig. 4, Plate XVIII.) in three-phase armoured cables, each having an area of 0·35 square inch, composed of 37 copper wires of No. 11 wire gauge, and enclosed in pitchpine casing (Fig. 5, Plate XVIII.) secured to steel-channel buntons (Fig. 6, Plate XVIII.). The joints of the casing (Fig. 5, Plate XVIII.) are arranged so that water cannot get to the cables so long as the casing remains undisturbed.

A junction-box is provided half-way down the shaft to relieve the weight of the cables; and at the pit-bottom, a main junction-box is fixed, from which the cables are distributed as required.

All the underground cables are laid in puddled-clay trenches, about 12 inches below the floor-level (Figs. 7 and 8, Plate XVIII.). The main cables, laid down the old engine-plane, are 0·35 square inch in area, insulated with prepared paper, jute and lead, and steel-armoured. These cables supply electric current to a motor of 50 horsepower for the No. 1 slant-haulage, and for an auxiliary haulage-motor of 10 horsepower on the north level, a motor of 7½ horsepower driving a pump in No. 3 slant, two motors of 50 horsepower at the junction of No. 4 slant-haulage, one motor of 7½ horsepower driving a pump at the far end of No. 4 slant, and two motors of 7½ horsepower, driving pumps at the junction of No. 4 slant. The cables supplying current to the north-level haulage are 0·06 square inch in area, and those supplying the pumps in No. 3 and No. 4 slants are 0·01 square inch in area.

No. 1 Slant and North District.—The haulage-gear shown in Fig. 11 (Plate XIX.) was adapted from a compressed-air plant, and although somewhat clumsy, it is nevertheless efficient. The No. 1 slant ropes are now hauling 288 tons in 8 hours a distance of about 2,100 feet, with a gradient against the load of 1 in 16, and the north-district ropes, 176 tons in 8 hours a distance of 3,000 feet, on a level gradient.

The cables supplying the current are 0·06 square inch each in area, and are composed of 19 wires of No. 16 wire gauge, insulated with prepared paper, jute and lead, and steel-wire armoured.

They are placed in a puddled-clay trench, in a similar manner to the main cables (Figs. 7 and 8, Plate XVIII.).

No. 4 Slant Junction.—The haulage-gear (Fig. 12, Plate XIX.) is arranged for three motors. At present, two motors of 50 horsepower are at work—one working the No. 3 south level, and the other the No. 4 slant ropes. The third motor will be installed when required. The gearing is arranged so that any one motor can be applied to drive either of the rope-drums, consequently the risk of a total stoppage from the failure of one motor will not result in a stoppage of the haulage on either of the roads.

This haulage-gear is provided with auto-starters and reversing-switches. The fuses are immersed in oil-baths (Figs. 13 and 14, Plate XIX.) for the purpose of avoiding the flame which would arise from a blown fuse. The whole of the switches, fuses and connexions, with the exception of the handles of the starting-switches, are enclosed in sheet-iron, lined with asbestos sheeting. Indiarubber mats, upon which men stand, are provided near the motors and switches.

A set of rules has been framed and put into use for the guidance of persons employed in connection with all parts of the electric plant.

The speed of the motors is 575 revolutions per minute.

In starting the gearing, the voltage generally falls about 120 volts when the load is thrown on to the motors by means of the friction-clutches; and this recovers automatically in a few seconds to the original voltage.

The coal being hauled by these motors is as follows:—

No. 4 Slant.—The distance is 4,500 feet, 381 tons are hauled in 8 hours, the gradient against the load for three-quarters of distance is 1 in 13, and for the remaining distance it is 1 in 40.

No. 3 South.—The distance is 1,200 feet, 460 tons are hauled in 8 hours, and the gradient of about 1 in 40 is in favour of the load.

Electric Pumping.—There is a motor of 30 horsepower at the pit-bottom, driving a Riedler differential pump, with plunger, 3½ inches in diameter at the large end and 2½ inches in diameter at the small end, with a stroke of 12 inches, and fitted

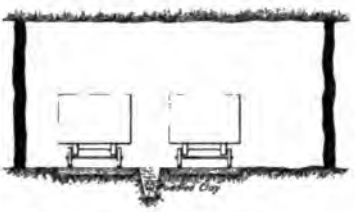


FIG. 7.—SECTION OF MAIN HAULAGE-ROAD SHOWING METHOD OF LAYING CABLE.

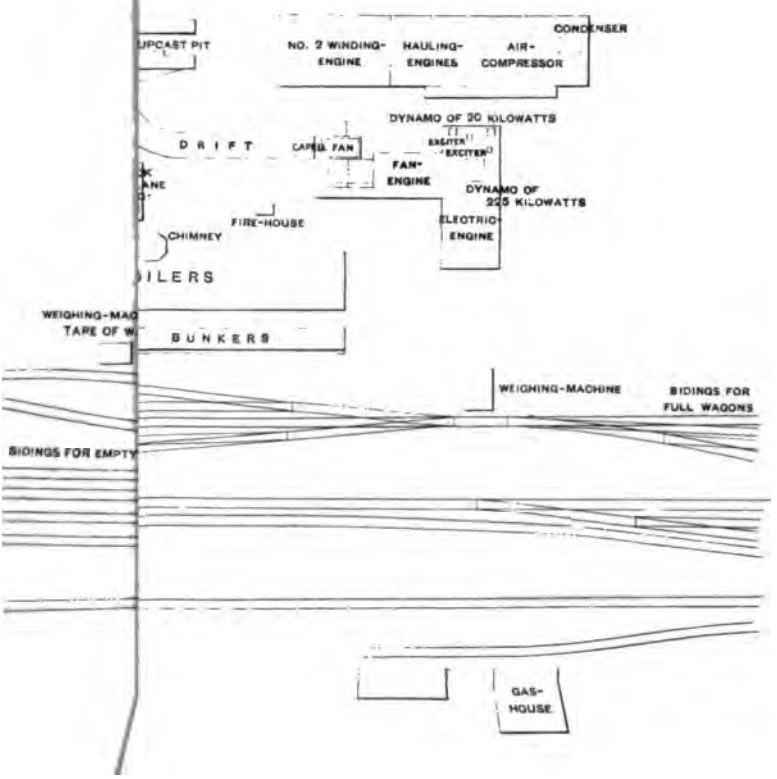
Scale, 8 Feet to 1 Inch.

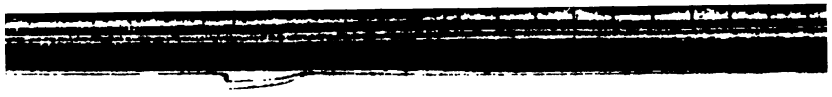
FIG. 8.—SECTION OF CABLE-TRENCH IN MAIN HAULAGE-ROAD.

Scale, 3 Feet to 1 Inch.

FIG.

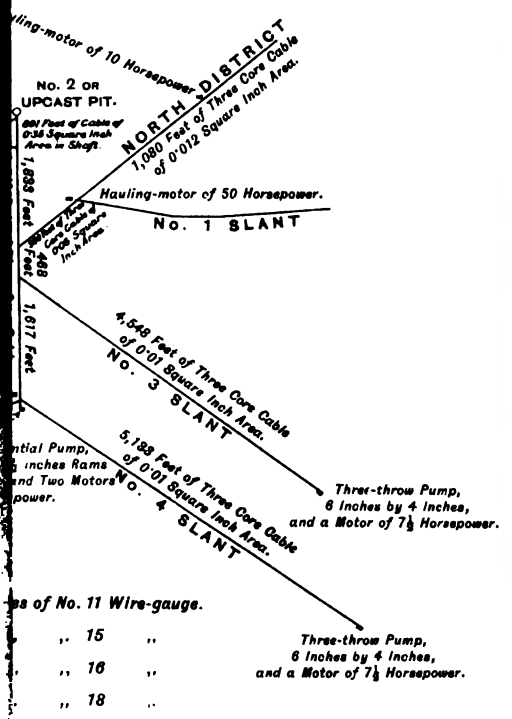
ASING ENCLOSING
SHAFT.
o 1 Inch.





Notes on Glapwell Colliery."

LENGTHS AND SIZES OF UNDERGROUND
S IN TOP HARD COAL-SEAM.

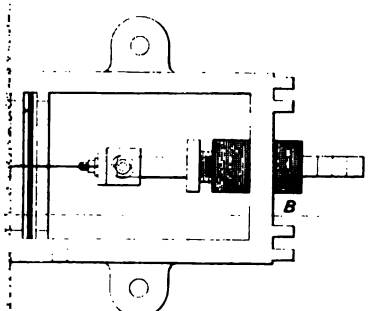

ling-motor of 10 Horsepower.
NO. 2 OR UPCAST PIT.
NORTH DISTRICT
1,080 Feet of Three Core Cable of 0·012 Square Inch Area.
Hauling-motor of 50 Horsepower.
NO. 1 SLANT
1,833 Feet
1,617 Feet
4,549 Feet of Three Core Cable of 0·01 Square Inch Area.
NO. 3 SLANT
5,198 Feet of Three Core Cable of 0·01 Square Inch Area.
NO. 4 SLANT
Three-throw Pump, 6 Inches by 4 Inches, and a Motor of 7½ Horsepower.
Three-throw Pump, 6 Inches by 4 Inches, and a Motor of 7½ Horsepower.

s of No. 11 Wire-gauge.

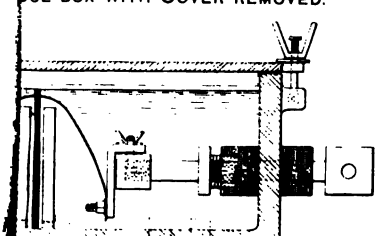
,, 15 ,,

,, 16 ,,

,, 18 ,,

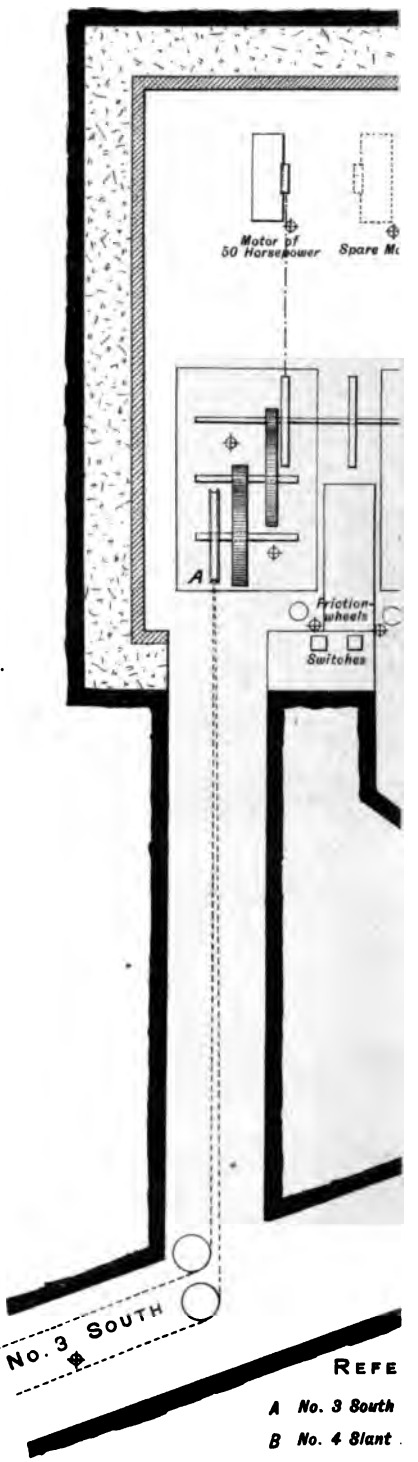


USE-BOX WITH COVER REMOVED.



ON LINE A.B. OF FIG. 13.

FIG. 12.—PLAN OF HAULAGE-GEA
AT JUNCTIO

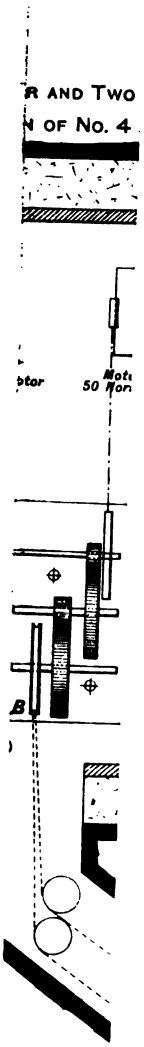


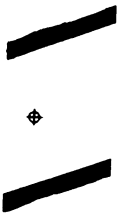
REFE

A No. 3 South

B No. 4 Slant

Electric Ligh





RENCES.

Rope-driving

Rope-driving

ts of 32 Can

with Riedler valve-gear. This pump has only been experimentally worked, as the work in connexion with the water-lodgment is incomplete. It is designed, when running at 150 revolutions per minute, to raise 60 gallons a minute against a head of 900 feet.

There are four electrically-driven pumps fixed underground.

A small Riedler express pump is used on the surface for pumping water for the boilers a distance of 2,700 feet. This pump has a ram 5½ inches in diameter by 7 inches stroke, runs at 200 revolutions per minute, and is driven by a motor of 7½ horsepower, running at 850 revolutions per minute. The efficiency of the pump is 90 per cent., the displacement of the rams at 202 revolutions per minute being 110 gallons, and the water actually pumped is 98 gallons per minute.

With regard to the efficiency of the electric plant, only very rough tests have as yet been made, and they are not sufficiently accurate to be of interest to the members. When the whole of the plant is at work, it is intended to make some careful tests as to efficiency and cost. The most practical results which have so far been observed, are larger outputs, due to increased hauling facilities, and a better supply of steam from a smaller number of boilers.

Electric Lighting.—The lighting-current is taken from the main-power cables, and reduced to 100 volts by means of a stationary transformer.

Mr. J. A. Longden (Stanton-by-Dale) said that 12 years ago he had tried the Caddy hollow fire-bar, which Mr. Deacon had found so satisfactory. He then satisfied himself that in regard to these particular boilers the economy was marked, and he went to the expense of applying them to all his boilers, hoping to obtain a similar economy, but the results obtained were not secured in actual practice. He then came to the conclusion that the Pillatt and Caddy fire-bars were wrong in principle, because they increased the volume of air passing through the furnace. The method that appeared to him to be most economical was the under-feed stoker, which gave improved results. In this system, the proper volume of air was

blown in, and complete combustion of the fuel was obtained. If the stoker was working satisfactorily, the ashes or residue were simply the ashes that were in the coal; and he (Mr. Longden) thought that no one could do better than that. He had used this stoker for some years, and it gave an efficiency of 25 per cent. out of the boilers greater than any other furnace. The coal was absolutely and perfectly burnt, and he (Mr. Longden) thought that if Mr. Deacon would look into the matter he would see that the idea of using hollow fire-bars and rushing in air was wrong in principle, and resulted in a greatly-increased consumption of coal, although it was true that the smoke was consumed. The colliery-consumption at the collieries with which he was connected had decreased from 8 to 3 per cent., and he considered that Mr. Deacon's 5½ per cent. from that point of view was less satisfactory.

The Rev. G. M. Capell (Passenham) remarked that the Capell fan at Glapwell colliery was one of improved type, but it was not of the same pattern as those now being erected. He considered that the comparison that Mr. Deacon had made between the two fans was very interesting: one fan being 40 feet and the other 12½ feet in diameter. He knew of many large fans of varied types which had been replaced by Capell fans, and, in many cases three times the amount of air, passed by the old fan was produced at three or four times greater water-gauge.

Mr. W. Price Abell (Duffield) said that the careful diagnosis submitted by Mr. Deacon was of value; for it was by such comparisons that engineers were able to put their finger on weak spots and thereby evolve improvements. At the same time, diagnoses must of necessity be qualified, otherwise the results might be entirely misleading, and in the present case it was only fair to the maker of the genuine Waddle fan to say that the fan under consideration and tested by Mr. Deacon was not a Waddle fan; that it was not either made or designed by Mr. Waddle, but was only an approximate imitation of one of his old types of fan, made by another firm now extinct. Furthermore, this particular open-running fan, mongrel though it be, was greatly handicapped, owing to its being too large for the mine; whereas the Capell fan had been made to suit the equi-

valent orifice of the mine: and as there was a fan already at the mine, data would be available, by which the equivalent orifice could be calculated, before ordering the Capell fan.

Mr. Isaac Hodges, alluding to the fact that there were three sets of endless haulage-ropes running in the shaft, thought that it would be conducive to economy if all the work was concentrated in one rope. He asked Mr. Deacon what amount of supervision was necessary for the three hauling-engines, as by having one only he would save attendants. He might say that in heavy haulage of this kind the old type of friction-gear was not always reliable, and frequently broke down; but the newer kinds was efficient, and, if centralized, one man could run it. He noticed that inbye pumps of only 7½ horsepower, situated 1 mile inbye of the main haulage-planes had separate electric power cables run to them. It would appear that whatever comparative efficiency resulted from the use of electricity in a case of that kind, it would be still cheaper if the pump was rope-driven. Could Mr. Deacon give the members any idea as to the relative cost? He was afraid that many of the data as to the saving of fuel at the boilers were useless, as they entirely depended upon the quality of the fuel used at the various collieries being taken into account. He had been misled in the past by taking the amount of fuel consumed and comparing it with the tonnage raised, and had found such data unreliable owing to good and bad fuel being used in different cases.

Mr. S. A. Everett (Gedling) said that the most interesting point in the paper was that of the economy of fuel. It was astonishing to find engineers making most expensive attachments to their engines, with the view of saving a little steam, and paying very little attention to the way in which the fuel was used at the boilers, where the opportunities for economy were vastly greater. He noticed that in the tests made by Mr. Deacon the consumption of fuel per square foot of fire-grate varied enormously, and was greatest in the case of No. 1 experiment, amounting to 25·2 pounds, and least in No. 4 experiment, amounting to 13·2 pounds. There also appeared to be a considerable variation in the amount of air admitted, judging from the analysis of the flue-gases, and also from the temperature of the

waste-gases at the end of the boiler. These results showed the difficulty of testing different appliances under anything like comparable conditions. He thought that the benefit to be derived from the use of hollow fire-bars, from the point of view of smoke-consumption, was somewhat doubtful; but the hollow fire-bar was more lasting, and this alone more than compensated for its greater initial cost. The underfeed stoker, giving absolute control over the air-supply, was an admirable appliance, but its price rendered its use prohibitive to some people.

He (Mr. Everett) would like to mention, now that three-phase work was being more generally introduced, that there ought to be some standardization as to periodicity and voltage. He would like to have information from Mr. Deacon as to the steam-consumption per kilowatt-hour of the slow-speed engine and the rope-driven generator at full, half, and quarter load. In deciding the question of generating-plant one had three alternatives:—(1) A slow-speed engine and a rope-driven generator; (2) a slow-speed engine and a direct-coupled generator; and (3) a high-speed direct-coupled generator. The first occupied much ground-space and was costly; the second was even more expensive; but the third, which found much favour for central-station work, was not quite the thing to entrust to colliery-workmen. He thought that the steam-turbine was admirably adapted for colliery-work, as it possessed the following advantages, over the other engines referred to:—It enabled the generator, on account of its high speed, to be constructed at a moderate cost; it needed practically no attention; it consumed no oil, as the only oil was in the bearings, and when once supplied could be used over and over again; and the wear-and-tear was very low. In sets of 200 kilowatts and over it competed successfully as regards price, and the steam-consumption was low. A 200 kilowatts set recently tested consumed only 19·4 pounds of steam per kilowatt-hour, equivalent to 11 pounds per indicated horsepower; and in larger units, a consumption of only about 8 pounds had been attained. He noticed that the engine driving the Capell fan consumed 1 pound less steam than the Robey engine: could Mr. Deacon give the explanation of this difference? From the fact that automatic starters were mentioned, it might be inferred that Mr. Deacon had adopted short-circuited motors. He (Mr. Everett)

would like to hear whether experience with these was satisfactory; or whether slip-ring machines with wound rotors were not preferred, in all cases where they had to be started with a load.

Mr. Hugh Waddle (Llanelly) wrote that the so-called Waddle fan at Glapwell colliery should be described as a fan of the open-running type. It had been made by another firm, and it was only a more or less approximate imitation of one of the obsolete patterns of the Waddle fan. Considering that the Capell fan was made of a size to suit the mine, whereas the old fan was far too large for the mine, and was further handicapped by a very small fan-drift, the difference in the efficiency of the fans, apart from the engines, was less than might have been expected. On a mine of double the equivalent orifice and with a suitably sized drift made for the open-running fan, it would no doubt show the higher efficiency of the two. In the experiments, it showed a higher manometric efficiency, in spite of the conditions being unfavourable to it. The experiments should preferably have been made upon the fans when running at the same periphery-speed and under the same mine-conditions.

Mr. Maurice Deacon, replying to the discussion, said that he was interested to hear that Mr. Longden had reduced his colliery-consumption from 8 to 3 per cent. Mr. Longden stated that the principle of introducing the air at the back of the bridge was wrong, but he (Mr. Deacon) ventured to think that nine out of every ten mining-engineers would not agree with Mr. Longden. The secret of reducing fuel-consumption was to admit air at that particular point of the furnace where there was a deficiency of air, and so obtain complete combustion. He knew the underfeed stoker, and was glad to hear that it was doing good work; but he was afraid that he was rather prejudiced against it, as when he had gone to see it at work it had broken down. His experience of mechanical stokers was that they cost more to keep in repair than they saved. The temperature of the gases given in his paper were very high, because the firing was forced, as they had been short of boiler-power. If the members referred to Table I. they would find that the highest temperature was attained when ordinary fire-bars were used.

He (Mr. Deacon) did not know that the fan was not a Waddle.

It had the shape of a Waddle fan, and they had always called it a Waddle fan, but if it had not been made by Mr. Waddle he supposed that it was not a Waddle fan. Of course, it was almost impossible to get two fans working upon the same mine and with all the conditions suitable for an absolute comparison.

He was very much interested in Mr. Hodges' remarks, which were very much to the point. But Mr. Hodges must remember that when they were dealing with old collieries they had to take them as they found them. It was all very well to take away three engines and substitute one to do their work, but in the case of an accident happening to the engine or the rope, he liked to have something to fall back upon. With regard to the third engine, however, no doubt it ought to be done away with; and that he would do as soon as he could spare the money. With regard to the inbye pumps, he was not going to take the driving rope any farther; but he was going to deal with the water of the future by electric pumps. The ropes had their full work to do, and, therefore, he did not propose to add any more to them. He was afraid that he could not help Mr. Hodges very much with reference to the calorific value of the fuel. He knew that it did vary considerably; with one kind the ash might be 25 per cent., and with another 8 or 9 per cent., or even less.

He had been interested in Mr Everett's remarks, which indicated a very careful study of all these important points. With regard to adjusting the air-feed to the amount of fuel, he (Mr. Deacon) quite agreed that that was nearing perfection, but it was extremely difficult to accomplish. He did not know of any apparatus by which the air could be admitted with anything like regularity in a hand-fired boiler, and he had a great objection to mechanical stokers, some of which were based upon wrong lines. He preferred to reduce his fuel-consumption, as he certainly thought he did, and certainly reduced the amount of smoke, by using something of a stationary character such as hollow bars; and he preferred this, to putting down an apparatus that was always breaking down.

He agreed with Mr. Everett in thinking that the standardization of electrical appliances was most desirable. He doubted very much whether they would get a standardization as long as they obtained their electric machinery from other countries.

With regard to the use of high-speed engines, he preferred a slow-speed engine both as regards efficiency and general advantage. A slow-speed rope-driven engine was better suited for colliery-work than a high-speed direct-driven engine.

The question had been raised as to the fan-engine consuming less steam than the electric engine. He (Mr. Deacon) did not think that this was due to any question of design; in fact it was due to the fan-engine having a bigger load upon it than the electric engine-plant; the latter had been put down with a view to extensions in the future, and was only working with about half its load and therefore not to the best advantage. Under the circumstances, it might be said to be extremely economical. He had put it down in his paper as using 15 pounds of steam, but the manager of the colliery declared that it only used 11 pounds.

The PRESIDENT (Mr. James C. Cadman) moved a vote of thanks to Mr. Deacon for his interesting paper.

Mr. I. HODGES seconded the resolution which was cordially approved.

Mr. F. C. SWALLOW read his paper on "Coal-mining in Warwickshire, with Special Reference to the Use of Stanley Coal-heading Machines in the Rapid Development and Working of the Nuneaton Colliery":—

COAL-MINING IN WARWICKSHIRE, WITH SPECIAL REFERENCE TO THE USE OF STANLEY COAL-HEADING MACHINES IN THE RAPID DEVELOPMENT AND WORKING OF THE NUNEATON COLLIERY.

By F. C. SWALLOW.

I. Introduction.

Coal-mining in Warwickshire has, until recent years, only been carried on at or near the eastern outcrop of the Coal-measures. Mining operations, along the margin of the coal-field in the neighbourhood of Bedworth, have existed for upwards of 100 years, and both coal-seams and ironstone-seams have been extensively worked.

This coal-field is the nearest of the British coal-fields, at present being worked, to the metropolis of England, and owing to communications therewith by both railway and canal, there has always been a ready market for the coal. Birmingham, Leicester and Coventry are also within a radius of 20 miles of the principal collieries of Warwickshire, to all of which there is direct communication by the Midland, and the London and North-western railways.

Prior to 1851, when the branch-line of the London and North-western railway between Coventry and Nuneaton was opened, the principal means of transport for coal and ironstone was the Coventry canal, opened in 1767. This canal runs from Coventry, by Longford, Bedworth, Nuneaton, Atherstone, and on to Fazely in the north, and there are loading-wharves in connection with the following collieries between the towns of Coventry and Tamworth, which are all situated near the line of outcrop of the Coal-measures, namely:—Exhall, Newdegate, Charity, Griff, Nuneaton, Badesley, Polesworth, Pooley and Tamworth. Exclusive of special rates, the freight for the transport of coal is ½d. per ton, per mile.

The Oxford canal adjoins the Coventry canal near the village of Bedworth; and about 2 miles to the north of Bedworth, there is a connection with the Ashby-de-la-Zouch canal. The canal is therefore largely employed for the transport of coal in barges, holding from 25 to 30 tons, and it can be thus shipped direct from the collieries to most of the Midland counties and also into the city of London.

This mode of transport is at once cheap and economical, as the large-sized house and steam-coal of this district is stacked into the boats by hand at loading-wharves, at or near the various collieries, and can be loaded and conveyed great distances with the minimum of breakage.

FIG. 2.—PIT-BANK AND CART-LOADING STAGE, NUNEATON COLLIERY.

The Nuneaton colliery is situated near the village of Whittleford, on the branch-line of the Midland railway between Nuneaton and Birmingham. This is one of a group of collieries the out-put of which, during the past ten years, has been increased from a few hundred tons to nearly 5,000 tons per day.

II. GEOLOGY.

The Coal-measures of this area of the Warwickshire coalfield repose upon Upper Cambrian or what may be termed the

Cambro-Silurian rocks, locally known as the Hartshill Quartzite and Stockingford Shales. This formation is largely quarried within 2 miles of the Nuneaton colliery.

The Hartshill Quartzite is a reddish vitreous quartzite, slightly micaceous, and is extensively quarried, crushed and sized, and sold for macadamizing purposes, for which it is admirably suited. Some of the roads, and especially the main turnpike-road or Watling Street which runs north and south about 3 miles to the east of Nuneaton, are some of the best in the country.

The ridge of these Cambro-Silurian rocks is a prominent feature of the district, where on Tuttle Hill it has an altitude of 490 feet above sea-level. The beds dip rapidly towards the south-east from Tuttle Hill, at an angle of about 25 degrees; and they pass immediately under the Coal-measures, dipping in the same direction. In the neighbourhood of Nuneaton colliery, the seams of coal have an inclination of about 16 degrees to the south-west. Thence, the angle of dip becomes gradually less, until at a distance of about 5,000 feet south-west of the colliery, the coal-seams have but a very slight dip and ultimately become practically level or undulating as the beds extend westward.

Rapid developments towards the centre of the coal-field are in progress. At Arley, situated about 5 miles to the south-west of Nuneaton, new shafts are being sunk. Newdegate colliery has commenced to work the principal seams of coal: it is situated about 1½ miles to the west of the town of Bedworth.

At the Charity colliery, Bedworth, the shafts have been sunk to a further depth of 417 feet below the Seven-feet coal-seam, and at a depth of about 183 feet below the Seven-feet seam, the shafts enter directly into the Cambro-Silurian shales. The Coal-measures rest unconformably upon these shales, the old rocks dip in the same direction as the Coal-measures at an angle of about 9 degrees, but the latter dip at an angle of about 16 degrees. The shafts have passed through 234 feet of Silurian shales, and cross-measure headings, slightly rising, are now being driven to win out a large tract of coal lying to the dip of the colliery.

The seams of the Warwickshire coal-field belong to the Upper Coal-measures of the Carboniferous system. Table I. contains a summary of the section of the strata passed through in the shafts of the Nuneaton colliery.

The approximate total thickness of the Upper Coal-measures in the neighbourhood of Stockingford is therefore about 780 feet.

TABLE I.—SECTION OF STRATA AT NUNEATON COLLIERY.

Formation.	Description of Strata.	Thickness of Strata. Ft.	In	Remarks.
Soil	... ...	1	0	
Lower Permian	Composed of an extremely variable series of beds of red, blue, brown, purple and yellow marls, varying from 1 foot to 12 feet in thickness, and increasing in hardness with the depth. They are apparently conformable with the Coal-measures, the latter being reached at a depth of 274 feet	273	0	Water-bearing strata, yielding about 12,000 gallons of water per hour occur between the depths of 99 and 171 feet from the surface. This water is coffered off.
Upper Section of the Upper Coal-measures	Consisting of very variable thicknesses of rock-binds, with balls of stone, dark fire-clays, sandstones and seams of ironstone, from the depth of 274 feet to the depth of 514 feet, when the Four-feet Coal-seam is reached	240	8	
Middle Section of the Upper Coal-measures	Between the Four-feet Coal-seam and the Seven-feet Coal-seam, at depths of 514 and 750 feet respectively from the surface, occur the principal workable coal-seams of the Warwickshire coal-field. Clod-binds, fire-clays and strong rocks, together with fire-clays containing balls of ironstone, which vary in size from a marble to balls about 30 inches in diameter	236	0	The total thickness of coal, in seams of 3 feet and over in the section, amounts to 31 feet 3 inches.
Lower Section of the Upper Coal-measures	Between the Seven-feet Coal-seam and the base of the Coal-measures, not proved in the neighbourhood of these shafts, although the remaining thickness of the Coal-measures will probably not exceed 300 feet as indicated at the outcrop to the east of Nuneaton colliery	Approximately 300	0	Several thin coal-seams occur, together with fire-clays, binds, rock, etc., and some valuable beds of ironstone.

The water emitted from the Lower Permian strata is of excellent quality. The first pair of shafts were sunk about 2,700 feet south-west of the present pits, but the water-feeders were

so heavy that the sinkings were stopped and the present position decided upon. The former shafts have been acquired by the Nuneaton and Chilvers Coton Urban District Council, who have erected pumping-machinery, and the water is now utilized as the main supply for Nuneaton and district.

III. Description of the Coal-seams.

Two-yards Coal-seam.—The principal seam of coal, at present being worked, is the Two-yards, reached at a depth of 558 feet below the surface. It is locally known as the Ryder coal-seam. An average section of this seam, comprising 6 feet 3 inches of coal, is as follows:—

		Ft. In.	Ft In
Roof:	Dark shaly bind	12 0	
		——	12 0
Seam:	**COAL**, Roofs, bright house-coal and steam-coal	0 6	
	COAL, Spires, having the appearance of cannel, an excellent house-coal	0 9	
	COAL, Ryder Hards, similar to the Spires, but of brighter lustre, a good house-coal	1 2	
	COAL, Brights, best house-coal	1 6	
	Stone, a pea-like conglomerate, intermixed with *coal*, varying in thickness from *nil* to	0 9	
	COAL, Brights, house and steam-coal	2 4	
Holing:	Dirt or soft fire-clay, from 1 inch to . .	0 9	
			7 9
Thill:	Fire-clay	0 6	
		——	0 6

The thill is composed of dark fire-clay about 6 inches thick, below which occurs the Bare coal-seam, containing about 3 feet 8 inches of coal of less valuable quality and not worked.

From the preceding section of the Ryder coal-seam, it will be seen that the roof is not good, and if roads were driven with this dark shaly bind immediately overhead, they would be costly to maintain. It is therefore advisable (unless the "breasting-out" system of working the coal is resorted to) to leave a good thickness of coal overhead in the roadways, and the roads should be kept as narrow as possible.

For the rapid opening-out and development of this seam, the Stanley coal-heading machine is eminently adapted; and usually an annular groove-machine, 5½ feet in diameter, is em-

ployed. The best position of the roadway is in the top portion of the Bare coal and in the bottom portion of the Ryder coal, leaving about 2 feet 8 inches of the Bare coal-seam for a floor, and 2 feet 9 inches of the Ryder coal-seam overhead as a roof. Circular roads, so driven, have been found to stand for many years without timber.

The Ryder is an excellent house-coal, and is the best of the three workable seams of this district. Under the system of working employed, the results recorded in Table II. are obtained when the coal is carefully worked and no blasting allowed except as directed by the management.

TABLE II.—QUALITIES AND CONDITION OF THE RYDER COAL-SEAM OBTAINED FOR SALE IN TRUCKS.

	Per-centage
1.—Best hand sorted bright house-coal: being large lumps, about 1 cubic foot and upwards in size	15
2.—Best hand-sorted coal, specially suited and in demand for house-coal: being lumps of Hards or Spires coal, about ½ cubic foot in size and upwards	10
3.—Hand-picked cobbles, which obtain a ready market for house-coal: being the Roofs and Bottoms coals, about ½ cubic foot in size ...	7
4.—Screened cobbles: being pieces which pass over perforations 3 inches in diameter on the screen on to which they have been elevated after passing the hand-sorters	37
5.—Screened cobbles: being the Hards or Spires coal, which is sorted from the cobbles-belt after passing over the screen with No. 4 class and loaded separately for locomotive and steam-raising purposes ...	2
6.—Nuts: being the screened coal which passes over perforations 2 inches in diameter, and through perforations 3 inches in diameter on the jigger and in demand for house-coal or kitchen-coal	10
7.—Double-screened nuts: being the screened coal which passes over meshes ½ inch in diameter and through a mesh 2 inches in diameter on the jigger, passing a second time over a plate having perforations ½ inch in diameter before being delivered to the picking-belt for cleaning. This coal is sold for steam-raising purposes and principally for mechanical stokers	12
8.—Smudge: the residue which passes through the mesh ½ inch in diameter, and is used for colliery-consumption and steam-raising ...	7

Slate Coal-seam.—The Slate coal-seam occurs at a depth of about 654 feet from the surface in the shafts at Nuneaton colliery, and lies about 96 feet below the Two-yards or Ryder coal-seam. The following is an average section of the seam, comprizing 10 feet 4 inches of coal, in this district:—

		Ft.	Ins	Ft.	Ins.
Roof:	Hard Sandstone		—		
	Dark binds, with layers of hard sandstone	16	0		
				16	0
Seams:	**COAL**, Tops or Roofs, good steam-coal	2	3		
	COAL, Spires, best locomotive-coal	0	9		
	COAL, Bench, best house-coal	3	4		
	Parting, from nil up to	1	3		
	COAL, Bottoms, house and steam-coal of a softer nature	4	0		
Holing:	Dirt or soft fire-clay from 3 inches to	0	9		
				12	4
Thill:	Fire-clay		—		

Of the three principal seams of the district, the Slate coal-seam is the best in which to drive out main roads, on account of the strong roof-stone. Roads, however, should be made as narrow as possible, and if driven with a Stanley heading-machine, 5½ feet in diameter, they should be driven under the Spires coal, which forms a very tough roof, and there is thus about 1 foot 10 inches of coal left underfoot. A circular road thus driven and left so, forms an excellent single-tub road, air-way or return air-course, and will stand many years without timber. When roads are driven out to win extensive royalties in the Slate coal-seam, the Two-yards and Seven-feet coal-seams would be worked by cross-measure drifts driven into them from the Slate coal-seam.

TABLE III.—QUALITIES AND CONDITION OF THE SLATE COAL-SEAM OBTAINED FOR SALE IN TRUCKS.

	Per-centage.
1.—Best hand-sorted bright house-coal: being large lumps of coal, about 1 cubic foot and upwards in size	10
2.—Best hand-sorted steam-coal: being large lumps averaging about ¾ cubic foot and upwards in size	37
3.—Hard hand-sorted steam-coal, specially suited for locomotive purposes: being lumps about ½ cubic foot and upwards in size	3
4.—Screened cobbles: being pieces which pass over a mesh 3 inches in diameter, in demand for household and steam-raising purposes ...	22
5.—Screened cobbles: of same size as No. 4, but hand-picked from the cobble-belt and loaded separately; it is an excellent locomotive coal	2
6.—Nuts: being pieces which pass over a mesh 2 inches in diameter and through a mesh 3 inches in diameter, forming a marketable house-coal	8
7.—Double-screened nuts: being the coal which passes over a mesh ½ inch in diameter and through a mesh 2 inches in diameter on to a second plate, having perforations ½ inch in diameter, over which the coal passes to the picking-belt, being thus twice screened	12
8.—Fine slack or smudge: being the residue which passes through a mesh ½ inch in diameter	6

Seven-feet Seam.—The Seven-feet coal-seam occurs at a depth of 738 feet below the surface in the Nuneaton shafts, or about 84 feet below the Slate coal-seam. The section of the seam, comprising 5 feet 2 inches of coal, in this district is as follows:- -

		Ft.	Ins.	Ft	Ins.
Roof:	Shaly bind, requiring careful timbering or support				
Seam:	**COAL**, Top, steam-coal	0	9		
	COAL, Middle, best house-coal	2	9		
	COAL, Bottom, steam-coal	1	8		
Holing:	Dirt or fire-clay, from a few inches to	2	0		
				7	2
Thill:	Damp fire-clay	19	0		
				19	0

From the preceding section it will be seen that, owing to the bad floor of the Seven-feet coal-seam, main roads driven in the coal and with this floor as a foundation are difficult and costly to maintain. The best road is obtained by breasting out the coal, about 36 feet wide and building good solid pack-walls, about 12 and 18 feet wide respectively, on either side, following up behind with lips or caunches of top-stone, and ultimately raising the roadway above the coal-seam altogether and into the rock-measures.

The Seven-feet seam is subject to frequent disturbances in its section, and a thinning or disappearance of the coal for distances of a few feet to many feet in length may be expected. The natural conditions and characteristics of this seam render it more expensive to work than either of the other seams previously described. The coal, however, is of excellent quality for household and steam-raising purposes, and, in some areas, is found to produce the best house-coal of the three principal seams of the coal-field.

IV. System of Working the Slate Coal-seam.

The system employed for working the Slate coal-seam, where the coal dips at an angle of about 16 degrees from the horizontal, is known as the Warwickshire system. This system of working is a modification of the longwall principle. Both advancing and retreating methods are adopted, where the "jigs" or "hills" range from 200 to as much as 450 feet apart. The tub-road is taken across the working-face of the coal, and is moved forward as the face advances. Occasionally, both the advancing and retreating systems of working may be in operation, from one

main level or haulage-road. Where this method can be applied, there is a maximum length of working-face available for coal-getting, from one main level or haulage-road; and thus a large output can be obtained from a limited area of coal-face. Labour is centralized, and the ventilation of the workings and roads is greatly simplified.

Fig. 1 (Plate XX.) is a plan of a part of the workings at Nuneaton colliery, where this system of work is employed. All the roads, shewn upon the plan, were driven by means of the Stanley heading-machines, 5½ or 7 feet in diameter: the machines being of the annular-groove type, and actuated by compressed air at an average pressure of about 45 pounds per square inch at the receiver on the surface (Fig. 3).

FIG. 3.—STANLEY COAL-HEADING MACHINE AT WORK IN SLATE COAL-SEAM, NUNEATON COLLIERY.

A record of the distances cut per shift by all the machines from which the following particulars are submitted (Table IV.) shews the work performed by one of the annular-groove machines 5½ feet in diameter, over a period of seven weeks: this being an average account of the work which is regularly performed by these machines.*

* This length of heading was driven between the distances of 1,989 and 3,158 feet respectively from the shafts.

TABLE IV.—VIDIMUS OF DISTANCES CUT PER SHIFT BY THE STANLEY HEADING-MACHINE, 5½ FEET IN DIAMETER.

Date.	First Shift. 6 a.m. to 2 p.m.	Second Shift. 2 p.m. to 10 p.m.	Third Shift. 10 p.m. to 6 a.m.	Total Distance.
1903.	Feet.	Feet.	Feet	Feet.
January 1	Men absent	7	9	16
,, 2	10½	10½	3½	24½
,, 3	8	4½	9	21½
,, 5	9	10	9	28
,, 6	Men absent	10½	7	17½
,, 7	6	5	9	20
,, 8	9	10	9	28
,, 9	12	13½	12	37½
,, 10	10	12	8	30
,, 12	Men absent	10	11	21
,, 13	8	9	10	27
,, 14	9	11	9	29
,, 15	13	10	10	33
,, 16	8	9	6	23
,, 17	10	6	5	21
,, 19	Men absent	9	9	18
,, 20	9	11	11	31
,, 21	9	12	11	32
,, 22	10	11	10	31
,, 23	5	14	13	32
,, 24	Men absent	Men absent	Men absent	Men absent
,, 26	do.	9	14	23
,, 27	10	6	9	25
,, 28	9	12	10	31
,, 29	10	9	10	29
,, 30	12	9	6	27
,, 31	8	11	10	29
February 2	Men absent	10	11	21
,, 3	7	12	2	21
,, 4	10	15	8	33
,, 5	8	9	12½	29½
,, 6	11	9	16½	36½
,, 7	10	12	10	32
,, 9	Men absent	9	13	22
,, 10	11	12	10	33
,, 11	16	15	16½	47½
,, 12	14	13	10	37
,, 13	17½	15½	18	51
,, 14	16	14	12	42
,, 16	Men absent	8½	10	18½
,, 17	8	Men absent	6	24
,, 18	12½	10½	13	36
Total distance driven				1,169

The working of each heading or machine is let to contractors, who usually employ a machine-driver and a filler. Owing to the large quantity of coal produced, the principal difficulty is to get the coal loaded fast enough in order to keep the heading clear. The contract includes a yardage-price for heading, together with a tonnage-rate for the coal loaded and trammed to a distance of 300 feet from the face.

The pair of headings or level courses (in this district termed gate-roads), being driven out to the boundary-hills or jigs (the former being roads driven out to the dip, the latter being the roads formed to the rise of the gate-road) are spaced 450 feet apart, the hills being driven with heading-machines and 5½ feet in diameter. These roads are perfectly straight, and being circular, having the Spires coal for a roof and about 1 foot 10 inches of coal underfoot as a floor, do not as a rule require any timber, neither do they require much, if any, repairs during the period in which the panel of coal is worked out or the line of coal-face has retreated back to the gate-road.

TABLE V.—DETAILS OF COST, ETC., OF DRIVING A HEADING, 5½ FEET IN DIAMETER FOR A DISTANCE OF 1,169 FEET BY MEANS OF AN ANNULAR-GROOVE STANLEY COAL-HEADING MACHINE IN THE SLATE COAL-SEAM, NUNEATON COLLIERY, FROM JANUARY 1ST TO FEBRUARY 18TH, 1903.

1.—Number of 8 hours' shifts worked, 114.

2.—Average distance cut per day of 3 shifts, 30¾ feet.

3.—Labour:

	Total Cost. £ s. d.			Cost per Foot. s. d.
Heading, 1,169 feet long produced 964 tons 5 cwts. of coal	143	12	0	
Fitter's time, sundry repairs, etc. ...	0	12	6	
Knife-sharpening	1	14	2	
Winding-engineman's time (one-sixth) attending to air-compressor	2	4	8	
	£148	3	4	2 6·42

4.—Stores:

Coal consumed at boilers, 482 tons of fine slack at 1s. 6d. per ton	36	3	0	
Engine-oil for coal-cutting machine and air-compressor	1	11	0	
Cylinder-oil	0	18	0	
Renewals of knives	0	11	0	
	£39	3	0	0 8·04

5.—Plant:

Boiler, engine-house, air-compressor, heading-machine, air-receivers, air-pipes, and labour fixing same: 5 per cent. interest and depreciation, for 2 months	£37	19	10	0 7·79
Totals	£225	6	2	3 10·25

6. Labour-cost of coal into tubs at a distance of 30 feet from the face ... ... 3s. 0·85d. per ton.

7. Total cost of coal into tubs at a distance of 300 feet from the face ... ... 4s. 8·06d. ,, ,,

8.—Average distance driven per week of 6 days ... ... 167 feet.

9.—Average earnings of contractors ... ... 8s. 4·77d. per shift

Refuge-holes are formed and spaced 10 yards apart.

The hills are driven 1,200 feet directly to the dip, where they are connected, right along the whole length of the coal-face to be opened out, by a level course driven by means of a heading-machine, 7 feet in diameter. Along the entire length of the opening-out level, the face of the coal is commenced to be worked and, as this is developed, pack-walls, 12 to 18 feet in thickness, are spaced apart, 12 to 18 feet, and running in a line with the dip.

The pack-walls are built with the holing-dirt or fire-clay and good stones obtained from the wastes and are built under the Spires coal. The Top coal and Spires is thus only wrought from the wastes.

The tub-road is laid across the face of the coal, and moved up as this advances.

The general system of work in a stall is as follows:—Holers, who are employed by the contractors or stallmen, commence at the entrance of the hill termed the way-head, and hole or undercut the coal in the holing-dirt or fire-clay below the seam, which varies from 3 inches to 9 inches in thickness. This dirt is cast behind on to the pack-walls, or into the wastes. A section of the coal is then readily worked up to the parting, which occurs about 3½ feet from the floor of the seam, thus undermining the Tops for a distance of from 8 to 9 feet. As the Tops are thus holed, spraggs and cockers are set at less and not more than 6 feet apart. The Tops, the best household and steam-raising coal, is the hardest portion of the seam, and after a day or two will be found to have parted from the Spires coal and to be resting upon the spraggs and cockers: the latter especially proving an admirable method of safe timbering, and preventing the coal from falling or slipping outward or downward.

The holing having been completed along probably the entire length of the stall let to the stallmen (the stall ranging 225 feet on either side of the hill or jig), the work of getting down the Top coal, about 4 feet in thickness, is then commenced. All refuse and loose holing-dirt is thoroughly cleaned up from below the coal. The spraggs and cockers are then withdrawn by cutting away the coal from under the head of the timber, commencing from the way-head; a buttock or lift is then

taken across the face, each way from the way-head; and the tub-road follows in. This work, requiring great care, is usually performed under the direct supervision of the stallmen. It is a frequent occurrence for the coal to fall, after the timber has been withdrawn at the buttock, in lumps weighing from 10 to 20 tons. This coal is carefully broken into lumps and loaded into the tubs by hand. The stallmen are paid a charter or hewing-price for the coal and slack loaded separately: the charter for coal being usually from 1s. 2d. to 1s. 6d. per ton higher than that for slack.

There are thus, usually, two buttocks being worked on each stall at one time from the way-head outwards, the undercutting being carried on behind, as the buttock advances, for the next length.

The remaining section of coal left, the Roofs coal, in the wastes, is wrought between the pack-walls by cutting upward along the sides of the pack-walls and withdrawing the timber.

During regular working, the whole length of coal-face will thus advance from 10 to 12 feet per week.

The procedure is the same in both the advancing and retreating methods, with the exception that in the former method the jigs have to be formed as the face advances. The jigs are usually kept about 9 feet wide for double tub-road, and two tips or top-caunches are taken down at a distance of from 30 to 45 feet back from the coal-face, and the road is thus raised above the original level of the top of the seam, thus burying the goaf on either side, and placing the jig-road in the hard rock-measures in which they ultimately stand well.

The pack-walls on either side of the jig, termed the wayhead pack-walls, are usually built from 18 to 24 feet thick, and are carefully and tightly built so as to strengthen the road. By raising the jigs, above the original level of the seam, and thus burying the goaf, the air is shut off from the goaf; and gob-fires, which are prevalent in this district, are avoided or minimized.

Haulage in the jigs is self-acting, when 1 to 6 tubs are run; and the rope-wheel or jigger-block is readily moved upwards as the jig is extended.

In the retreating system of working, the roads, formed in the coal, are left circular and only wide enough for a single road. In this system some means of mechanical haulage must be provided.

At the Nuneaton colliery, a continuous-current electric plant is installed, and generates current at 500 volts for driving the main endless-rope haulage underground, and also for the secondary haulage and for pumping.

This power is specially applicable for operating the haulage-engines or gears required at the top of each of the hills. These gears are driven by motors of 10 horsepower, and are capable of hauling 3 loaded tubs up the inclines at one time, and raise from 80 to 100 tons per day of 8 hours from the faces to the main level or gate-road. Thus an output of from 560 to 700 tons per day is obtainable from the retreating line of coal-face alone.

FIG 4. SHED CONTAINING SORTING-BELTS, ETC.

Slow-moving endless-rope haulage operates the tubs to and from the shaft-bottom, and grooved plates are provided at the required places for the purpose of handling the tubs.

At the top and bottom of each hill, safety-gates are provided (Fig. 1, Plate XX.). These are constructed of a tram-rail, hinged at one end to a vertical rail or girder, and made to shut automatically against a strongly-fixed prop or girder at the other end. The horizontal rail or gate is placed about 2 feet above the rail-level, and provides a reliable safeguard against runaway

tubs, the gate placed at the bottom of the hills being also a protection for the men working there.

V. Sorting and Preparing the Coal for Market.

The sorting, sizing and ridding the coal of all foreign material, and thus preparing it for an increasingly competitive market, is one of the most important branches of the working of modern collieries. This is more especially so when the output exceeds 1,000 tons per day, as it is obviously necessary to employ the most reliable and efficient appliances possible to treat so large a quantity with a minimum of labour.

Fig. 5.—Main Sorting-belt, and Workmen loading Lump-coal into Trucks.

From 45 to 55 per cent. of the output of Warwickshire collieries is loaded into trucks by hand; and this is unavoidable, as the trade demands as great a percentage of large coal as possible (Fig. 5). For this reason, the charter or hewing-prices usually provide for the loading of the tubs at the coal-faces with the large coal and slack separately.

To enable the hand-sorting to be performed with the least amount of manual labour, it is now the practice to employ the following procedure:—(1) The loaded tubs are tipped mechanically from the tipping-level, which is about 16 feet above the

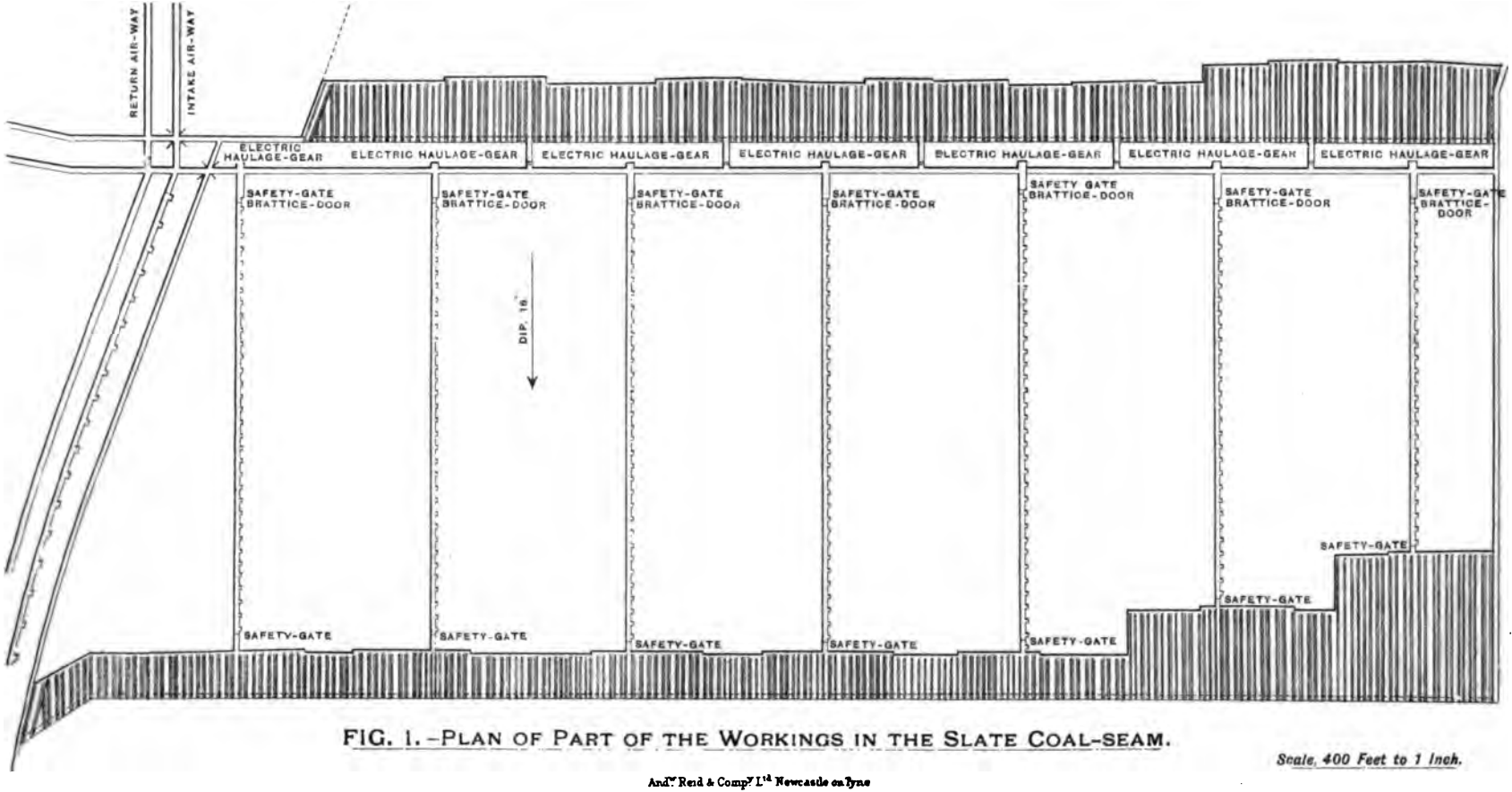
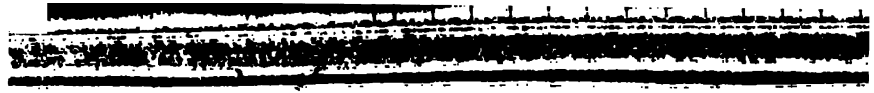


FIG. 1.—PLAN OF PART OF THE WORKINGS IN THE SLATE COAL-SEAM.

Scale, 400 Feet to 1 Inch.

And.ᵛ Reid & Comp.ʸ L.ᵗᵈ Newcastle on Tyne



truck-rail level, and the coal passes over screen-bars spaced 2 inches apart on to the main sorting-belt, travelling at the rate of 20 feet per minute. This belt is placed 8 feet above truck-rail level. It is obvious that the slack, from any tub, falling through on to the slowly-moving belt below, and passing under the large lumps of coal, acts as a cushion and prevents the breakage of the coal. (2) The coal or slack, being delivered on to the main belt, is then sorted. This belt, 4 feet wide, and 233 feet long from centre to centre, including the elevator which rises 13 feet in a distance of 32 feet, is constructed of steel-plates, 4 feet by 1 foot 1 inch and ¼ inch thick, fixed on links, and runs on rollers placed 4 feet apart. The length of the belt, from which coal is hand-sorted, is about 200 feet, and from 14 to 20 trucks of various qualities of coal can be loaded at one time, a truck-railway being laid along each side of the belt. The remaining quantity of the coal (from 45 to 55 per cent. of the output) is then raised by the elevator to a height of 21 feet above the rail-level on to the jigging screen, where it is sized and cleaned on picking-belts.

As the coal slowly passes along the lengthy sorting-belt, the various qualities are selected by experienced workmen (standing on stages, running along each side of the belt) who know the qualities thoroughly, and who lift the lumps on to a board placed on the side of the truck which is being loaded, where, if necessary, the coal is dressed or freed from any foreign material. The lump is then taken by lads standing in the trucks who stack the coal. It is most satisfactory to employ separate loaders, who load nothing but one particular quality of coal. From this sorting-belt, from 50 to 60 tons per day of 8 hours will be thus loaded by each set of two men and a lad.

Mr. Maurice Deacon (Glapwell Colliery) asked whether the disc-heading-machine was now in use at Nuneaton colliery. He had seen one at work which was heading at a very much more rapid rate than the annular-grove machine. He presumed that the heading-machine was driven by compressed air, and, if so, did the writer rely upon the compressed air for ventilating his headings, or did he find it necessary to ventilate by pipes? He would also like to ask the writer of the paper what would

guide him in deciding as to the system of working to be employed in a mine which was subject to gob-fires, where there was water, and where the seams were nearly flat. Would he adopt the hill or jig system under such circumstances? What would be the facts that determined him in adopting either one or the other of the two systems mentioned in his paper?

Mr. JOHN GERRARD (H.M. Inspector of Mines, Manchester) asked Mr. Swallow whether he could give any information as to the working of the Stanley heading-machine, parallel so to speak, instead of driving the heading continuously, that is, to make the usual cut forward, and then to withdraw the machine and make another cut alongside of the first; as this method would facilitate the removal of the coal. He thought that this system was being tried in Lancashire, and, so far, successfully.

Mr. J. LIDDELL (Wyken Colliery, Coventry) wrote that the experience that he had had with a Stanley heading-machine during the past 18 months led him to appreciate fully Mr. Swallow's remarks as to its utility in thick seams where rapid development was necessary.

Mr. J. T. BROWNE (Griff Colliery, Nuneaton) pointed out that coal-mining operations had been carried on in the neighbourhood of Nuneaton from a much earlier date than that given by Mr. Swallow in his paper. There was no reliable evidence that coal was actually worked before 1600, but it was on record that, 300 years ago, Sir John Newdigate, of Arbury, owned pits and worked the outcrop-coal at Griff and Chilvers Coton.

Stanley heading-machines had been in use continuously for the past ten years at the collieries with which he (Mr. Browne) was connected, and had been employed in developing all the workable seams on the system explained in the paper. The first range of hills driven in the Slate coal-seam had been worked out at an exceedingly low cost in repairs and timber, but, more recently, to the dip where the cover was heavy, hills similarly driven did not stand, and the repairs became so onerous as to necessitate an abandonment of the system in favour of jigs. He quite agreed that machine-headings were unsatisfactory in the Seven-feet coal-seam, owing to the thinness of the seam and the frequent occurrence of "stones," and probably the best

system of driving levels was that advocated by Mr. Swallow in his paper.

With regard to the fore-winning or retreating system, he would like to ask Mr. Swallow whether he had experienced any difficulty on the main-haulage gate-road as the coal-faces approached it. In his experience, the last 180 feet of working up to the gate-road was attended with heavy expense in keeping the roads in repair, and although this difficulty might be somewhat overcome by working the end places first, the loss of a certain amount of coal seemed inevitable.

He congratulated Mr. Swallow on the results shewn by the heading-machines, and also upon the low cost of driving. Were these figures taken from results obtained by machines driving level roads or hills? His experience was that, when working on the level, the machines were able to do much better than to the dip. He found that considerable time was lost in making repairs, and the wages of fitters employed, and the cost of the renewal of parts, amounted to a considerable item. On the whole, he had come to the conclusion that there was very little difference in the cost between hand and machine-heading, but for opening-out faces of work quickly, and for rapidly gaining an output, the Stanley heading-machine possessed undoubted advantages where the seams were thick enough to permit of the whole cut being made in the coal.

Mr. A. B. Hewitt (Stanton Colliery) asked whether the 5,000 tons per day was drawn from one shaft, and how many men were employed belowground and turning out this amount of coal, how many shifts they turned, and what was the duration of their shifts. He also asked what percentage of small was made by the Stanley heading-machine, and how long it took to fill out the coals before heading could be recommenced, especially as shewn in Table IV. for February 13th, 1903: here the cutting averaged 17 feet per shift, and 303¾ cubic feet of coal were filled in each shift. He would also like to know how many men were employed in the heading.

Mr. H. Richardson Hewitt (H.M. Inspector of Mines, Derby) said that the coal-mining industry in Warwickshire was now becoming an important factor in the development of the mineral resources of the country, and statistics showed that

the yearly output was increasing very rapidly, owing to the development of the coal-seams lying to the dip of the older collieries.

Owing to the spontaneous combustion of goaf-material, it was the practice to sink the shafts on the rise side of the royalty, so that all of the development was to the dip, and consequently heavy haulage-plants were essential. The coal-seams were thick, and as a consequence all slack was left in the goaf, adding to the danger of combustion of the material left behind: but against this must be set the fact that the hills were wet, and the goaf was partially or completely filled with water as the face advanced, hence, regular working was in many of the mines an absolute necessity to prevent the flooding of the workings. All workings to the rise must have substantial pillars for the protection of the main level, so that stoppings might be put in at any time.

The safety-gate described by Mr. Swallow was an excellent arrangement for the protection of the men working near the bottom of the hill, and was an arrangement which should be generally adopted in Warwickshire mines. The opening headings all worked down-hill and a similar arrangement was required for the protection of the headers working at the machine.

The Stanley heading-machine was useful in rapidly opening out a mine, but it had the disadvantage of leaving a road only 5½ feet in diameter. Part of this was reduced by débris on the floor, upon which the sleepers and rails were placed, so that the ultimate height of the road was frequently only 4½ feet, a tub-road and nothing more. For making a better road, two machines had been coupled together, or one machine had driven two circular cutters, but for some reason (which Mr. Swallow might explain) their use had been discontinued.

In opening out a colliery in Derbyshire some years ago, the Stanley header was employed, and worked successfully, but as the road was not large enough for the requirements of this mine, the sides and top of the roadways were removed, though with some difficulty, the coal being so remarkably hard.

In some Warwickshire mines, the roads driven by the machine stood exactly as driven as long as the road was required, whereas in others, the sides and top were so friable that they rolled off behind the machine with the consequence that a better road was made.

Another disadvantage of driving with the heading-machine was that no provision was made for ventilating by pipes or sheets, as there was no room for these. The machine was only working for a few minutes each hour, as the other time was occupied in removing and loading the coal. The exhaust-air from the machine gave 707 cubic feet of air per minute, and when the machine was not working, a ½ inch tap was left open in the pressure-pipes, which only gave a quantity of 84 cubic feet of air per minute, for the ventilation of the heading and the three men working there, a quantity totally inadequate in a heading where gas was being given off.

Mr. F. C. Swallow (Nuneaton Colliery), replying to the discussion, said that the disc heading-machine was not so advantageous in Warwickshire as the annular-groove machine, as the latter produced more large coal. He believed that even greater speed could be obtained in heading, by means of the disc or full-cut machine. The annular-groove machine, 5½ feet in diameter, where the cut was 3 inches wide, produced from 20 to 30 per cent. of slack and 70 to 80 per cent. of coal: this was, he thought, a very valuable factor in favour of the machine, especially in Warwickshire, where coal obtained much better prices than slack. The motive power adopted for the driving of the machine was compressed air, which he thought was preferable for headings, and, especially, winning headings, to electric power, as much greater distances could be driven before "thirls" or connecting-places, between the pair of headings need be made. The exhaust-air, and also the escape-air from the valve or cock, fitted to each machine for the purpose, provided an excellent means of ventilating the heading.

When the fore-winning or retreating-system of working was adopted, the far-end stalls were pushed forward and the progress of the outer stalls retarded, when the line of coal-face approached within about 180 feet of the gate-road. As the farthest-in hills became expensive to maintain, they were abandoned, and the tubs were taken along the coal-face to the next hill on the outbye side. The gate-road was also abandoned between the two hills. The basset-stalls, however, should by this time have reached the boundary, or the goaf of the panel beyond; and the working of the retreating-line of coal-face

was so regulated that the basset-coal was exhausted before the deep-coal rib became too thin.

The difficulty mentioned by Mr. Browne, however, was by no means easily overcome, and the cost of working the remaining distance of 180 feet was liable to become greater than the coal was worth, owing to the increased tramming expense and reduced output, together with the fact that the coal became crushed as the rib thinned. He (Mr. Swallow) proposed adopting the following system of removing the remaining rib of about 180 feet in another district, when the face had reached the point where the cost of road-repairs on the level above and in the hills began to be excessive, namely:—Forming a gob-road or cross-gateroad, along the line of the coal-face at that point, abandoning the level above and the hills, withdrawing all rails, timber, etc., from them and working the remaining rib on the jig principle: the jig-roads being placed about midway between the original hill-roads.

The output mentioned in the paper was the aggregate output from all the collieries comprised in the group, in the neighbourhood of Stockingford. When a constant supply of tubs was provided, the coal from any heading-machine could be readily filled and trammed away as it was cut: one man and a lad usually performed this work. In the driving of dip-hills, a hauling-engine was fixed at the top of the hill, to haul from either one or two hills. A cut of 17 feet would represent about 27 or 28 tubs of coal and slack, which could be filled into the tubs by one man and a lad in one shift. There was a machine-driver, a filler, and a trammer employed in each heading: the last-named usually assisted in the loading of the tubs.

The system of working by hills or jigs would be abandoned where the seams were flat or undulating, and the "breasting-out" system would be adopted. He (Mr. Swallow) had never worked one machine behind another, in order to form a wide road: double-cut machines were made for this purpose, but he had not worked a machine of this kind, and was, therefore, unable to give any opinion as to the method suggested.

The heading-machines used at Griff colliery were among the first made and of a lighter type than those of later date. If used for driving headings in seams of coal interbedded with hard stone-bands or strata, as was the case at Griff colliery, there was

undoubtedly risk of breakage; but in a seam of pure coal, with ordinary collier's care, there was little or no breakage in the modern type of the Stanley machine. This was proved by the record (Table IV.) contained in the paper. The fact of the machines used at Griff Colliery, such as they were, having been in continuous use for upwards of ten years was ample proof of their value. For the same reason, the retreating method of working the coal would not be used unless the system was advantageous.

The distance cut by the Stanley header as shewn on Table IV. for February 13, 1903, yielded about 34 tons, and the average number of tubs loaded per shift was 24. The number of men employed in the heading was one machine driver, one headsman, who cleared away the coal as it was cut from the face, throwing it behind the machine, and one tub-filler and trammer per shift.

The PRESIDENT (Mr. J. C. Cadman) moved a vote of thanks to Mr. Swallow for his paper.

Mr. H. C. PEAKE seconded the resolution, which was cordially approved.

Mr. GEORGE L. GRIFFITH's "Notes of Surveys and Levellings in Canada" were read as follows:—

NOTES OF SURVEYS AND LEVELLINGS IN CANADA.

By GEORGE L. GRIFFITH, Winnipeg, Canada.

A combined transit and levelling instrument for accurate work in general land, city, mine and railroad-surveying, has been put on the market by Messrs. John Davis & Son, Derby, Limited (Fig. 1).

Fig 1.—Transit and Levelling Instrument.

The writer obtained one of these instruments nearly a year ago, and it appeared to him that he could not do better than describe the various uses to which it had been put during that time, in a varied and diversified practice, coupled with some hints regarding the prevention of errors in instrument-work, culled from various sources and his own experience, which may be acceptable to the younger members of the profession.

Railway-surveys.

In June, 1902, the writer was engaged to make a preliminary survey in township 13, range 7 east of the principal meridian for the purpose of defining the best location for branch railways from Tyndal station on the Canadian Pacific railway to stone-quarries owned by Messrs. J. Gunn & Sons and Messrs. W. Henry & Son. Setting up the instrument at the first station, the writer made

an astronomical observation for the azimuth of the first line; afterwards, at that and the succeeding stations, the angles of intersection, magnetic bearing, levels by vertical circle and bubble distance with stadia, slope angles and topography were taken, all at one setting of the instrument; and with a party of three men the writer was able to make as rapid progress as he had made under similar circumstances with six or eight men. In this case, the accuracy of the levels was of prime importance, as the embankment-fill and the floor-level of a pile-bridge over Devil's Creek would be governed thereby. The object in view was to establish a grade so that the loaded cars would run by gravity from the quarries to the siding at Tyndal station. The topography was taken for a distance of 400 to 500 feet on each side of the centre-line. In a circuit of 6 miles, the levels closed on the bench-mark with an error of $\frac{1}{2}$ inch. In the final location, the writer ran the centre-line curves with cubic parabola transitions, set grade and slope stakes, at each setting of the instrument. The total cost of the work, including all plans and incidental expenses, was £6 (29 dollars) per mile.

In work of this kind, while running a line in one direction the 14 feet self-reading rod, graduated to 0·01 foot, is used, being read to the nearest 0·01. The rod is first read direct on the turning-point, and then reversed end to end and read from the top downward. Thus, two lines are carried along which should remain exactly 14 feet apart; by this method, eliminating all accidental errors, the writer has found, with ordinary care, that as good levelling can be done with the level on a transit-telescope as with a regular Y or dumpy level, thus saving the engineer many miles of tramping and wading through swamps in drainage and road-surveys by running both the transit and grade lines at one operation.

Some engineers claim that triangular plates, with three levelling-screws, are an advantage because the instrument can be levelled with one hand only, whereas, with four screws both hands are required. But the writer must confess that he has a strong prejudice in favour of the old system, as the levelling can be done more conveniently and quickly with four screws than with three, and the construction of the tripod for the four-screwed arrangement is far more satisfactory, ensuring greater accuracy in use and safety in carrying.

Drainage-surveys.

Red River Valley.—In making the preliminary survey of drainage-district No. 4, in townships 3, 4, 5 and 6, ranges 3, 4 and 5 (about 190 square miles in area); and drainage-district No. 5 in townships 7, 8 and 9, ranges 4, 5 and 6 west of the principal meridian (averaging about 200 square miles in area), in this Province for the Provincial Government, the writer found that the boundaries of the marshes could be traversed, located and measured by transit and stadia, more quickly and cheaply, and just as well as by the most elaborate chain or tape-measurement. The stadia-courses starting at a township or section-corner averaged from 1½ to 2 miles in length, with from twelve to fifteen angles, long stadia-lines being avoided as much as possible. They were made to close within a maximum error of 5 minutes in azimuth, one in one-thousand in distance, and 0·1 foot in elevation. Considerable change of focus causes, the writer finds, error in the measurement, therefore considerable change should be avoided as much as possible. Good levelling should check within 0·05 foot into the square root of the length of the circuit in miles.

The angles were always read to the nearest minute, simply because the work did not require closer reading except on triangulation-stations, the surveys having been made, not to mark the exact limits of properties, but to furnish the information necessary to make the plans for the economical construction of the main channel or canals, to determine the grades to be adopted, and to estimate the amount of excavation and the cost of the work, and the approximate area of the lands benefited belonging to each owner. The accuracy adopted was regarded as quite sufficient for these requirements, and the expense of the survey was materially less than is usually the case in such work, the total cost of the survey including all expenses and plans complete, being only 9d. (18 cents) per acre. By the carrying out of these drainage-schemes, land which was previously worth from 12s. 6d. to £1 (3 to 5 dollars) per acre has been sold for £1 13s. to £3 15s. (8 to 18 dollars) per acre. The total cost of the drainage-works (being the capital borrowed and interest) apportioned among the land-owners is 3s. 6½d. (85 cents.) per acre, repayable in twenty years.

Road-surveys.

In October, 1902, in running the traverse of a Government colonization-road, 1½ chains (99 feet wide) through sections 27, 26, 33 and 34, township 20, range 1 west of the first principal meridian, a total distance of 16,000 feet, the writer's stadia-measurements closed with a difference of 25 feet as compared with the precise chaining with a standardized Chesterman steel-band. The horizontal distance may be most quickly read by raising or lowering the telescope until the lower cross-wire comes on the nearest even foot-mark and then reading the upper wire; or, what is better still, when a stadia-reading is desired, instruct the rodman to invert his rod, then set one cross-hair on the upper end of the rod, which, numerically, was the bottom of the rod, the reading can then be taken to the other cross-hair. By this method, distances can be obtained with a considerable degree of accuracy.

The most approved method of running a traverse is that in which the graduated plate or limb of the transit is so set at each station that the azimuth of each line there observed can be directly read. The telescope is not reversed during any part of the work. In traverse-surveying, there will generally be some 2 or 3 minutes difference in closing, even with the most careful work, unless the readings are always made to 5, 10 or 15 minutes, etc., according to convenience, by moving the aligning pole a little to the right or left.

In running the traverse along a road, the angles have always been measured to the right, thus avoiding any possibility of deflecting the course on the wrong side when plotting.

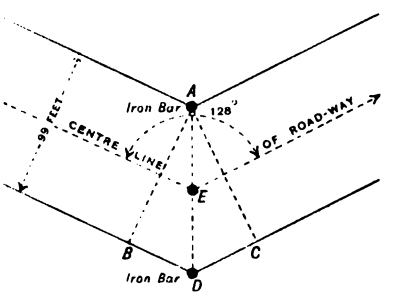


Fig. 2. Road-survey.

The northern and southern limits of the highway were defined by iron-bars, ¾ inch by ¾ inch, and 3 feet long, driven perdicular with a sledge to within 10 inches of the surface of the ground at the intersection of each angle.*

* The formula for setting the iron-bars, at the intersection of an angle (Fig. 2) is as follows: –

$128° \div 2 = 64°$. $90° - 64° = 26° =$ Angle A.

Secant A × 99 feet = AD. AD ÷ 2 = EA = ED.

Great care should be exercised in setting station-poles, to place them over their central mark and in making them securely and exactly vertical; also in centreing the instrument over the station-marks when observing. "The instrument should be set up firmly with the plates nearly level, and thus save much time in turning the levelling screws besides the worse than useless wear upon them." To do this, set up the instrument approximately over the desired point, hold firmly the leg of the tripod on the left with the left-hand and move the foot of the leg on the right with the right-hand in any direction, so as to bring the lower plate of the tripod approximately horizontal, determined by bending the body and placing the eyes in the plane of its upper surface and sighting as nearly as may be to the distant horizon. The sight is so long that, according to the principle of the "division of errors," the plate can be really set nearly horizontal, almost in any position of the instrument. Now place the left hip against one leg; grasp the opposite leg with the left hand and the leg of the right by the right hand; and, keeping the relative position of the legs unaltered, move the instrument laterally over the desired point and lower it to the ground. Of course the two movements of tilting and sliding may be done together, and in much less time than to describe the movement.*

Astronomical Observations for Azimuth.

Before commencing the traverse of this road, an excellent opportunity was afforded the writer for subjecting the transit to some severe tests. The first principal meridian which forms the easterly boundary of the township was run last year by Mr. Robert Bourne, Dominion land-surveyor, and the "hubs" on this line were still undisturbed. The writer set up the transit over the iron-bar at the township corner and took observations for longitude and latitude and with only one pair of observations in each case checked within 30 seconds of the precise line laid down by Mr. Bourne, with a much larger instrument and a series of observations. The determination of true azimuth should be a part of all property-surveys, road-surveys, mining-surveys and railroad-surveys. It will usually be possible so to plan the work that observations for latitude, longitude and time may be taken without wasting time or interfering with other work.

* *Field-manual for Engineers*, by Mr. P. Philbrick.

Mr. Cyrus Carrol, a Dominion land-surveyor of much experience, says that:—

> For timber-limits, mining locations, subdivisions of townships, subdivisions of sections or lots, an approximation as near as 20 seconds to the true direction is as near as it is of any use to make it, being only 6 inches in a mile, which, unless the line be run with two picket-men, back-targets, setting two or three points forward, at ¼ mile apart, testing to see if all is in line, and then on moving forward, test the last few points backwards, aligning on the target, using tacks and shingle-nails as points, he says, unless the line be so run, the deviations from a straight line will be more than 20 or 30 seconds of azimuth would cover.

Young men fresh from college, who are very fond of telling how they ran long lines of levels with a closing error too small to be measured and long traverse-lines closing with an error of 2 or 3 seconds, but who, in the field, make errors of feet in their levels and degrees in their angles, will ridicule this, yet old surveyors like the writer, well know how true it is.

The reading of the horizontal circle on the reference-object, generally one of the line-pickets (if possible, at least ½ mile from the observer) should be taken in both positions of the instrument, and the approximate time of observation noted. The best time for observation is when the sun is near the prime vertical, that is to say nearly due east or west. The following formulæ may be used for the calculation:—Cos. $\frac{1}{2} Z = \sqrt{\text{cos. } S \text{ cos. } (S - \triangle) \text{ sec. } \phi \text{ sec. } h}$; where $S = (h + \phi + \triangle) \div 2$; h, being the true altitude of the sun; ϕ, the latitude; $\triangle$, the sun's polar distance; and Z, the angular distance between the sun and the north-point.

Reckoning the azimuth from zero at the north-point round through east 90 degrees, south 180 degrees, and west 270 degrees, Z is the azimuth in the forenoon and minus 360 degrees the azimuth in the afternoon.

With the complete vertical circle on the transit, one-half of the observations should be taken with the instrument reversed. This has the effect of eliminating all index-error of the vertical circle, the error of collimation and the error due to difference of height of the telescope-standards. If the observations are taken in diagonal corners of the fields of view (Fig. 3), even the correction for the semi-diameter of the sun is eliminated. In the forenoon observe the sun's image as shown, and in the forenoon use

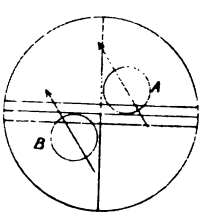


FIG. 3.—OBSERVATIONS FOR AZIMUTH.

the opposite corners. The instrument is provided with a coloured glass, which enables the surveyor to look at the sun through the telescope.

A simple and indeed very accurate method of staking out a true meridian in northern latitudes for determining the azimuth of lines is as follows:—The pole star, Polaris, revolves around the pole in a small circle, and crosses the meridian or culminates twice each day. Mizar, the middle one of the three stars in the tail of the Great Bear, or handle of the Great Dipper, revolves around the pole in a great circle, and in 1902 Polaris culminates 3 minutes and 17 seconds after it and Mizar are in the same vertical circle; and in 1905, about 4 minutes and 20 seconds after, the annual increase being 21 seconds. "To obtain the true meridian, set up a transit with a full vertical circle about ½ hour before the two stars are in the same vertical; the transit must be in good adjustment, particularly in respect of collimation and the horizontal axis of the telescope. Sight alternately upon Polaris and Mizar, and note by a watch the time when they are upon the same vertical, then, after the expiration of the interval above mentioned turn the vertical hair upon Polaris and the line of sight will then coincide with the true meridian."*

Although it is probably true that many surveyors do not find it necessary to take azimuth-observations very often, the writer thinks that the time is coming, and probably very soon, when all registered plans and descriptions will have to show the true astronomical course, and each surveyor should fix on some method that he may practice and familiarize himself with, and it will be of great value to him in the future.

The combined transit and levelling-instrument made by Messrs. John Davis & Sons, enables the surveyor to establish the true meridian, to determine the correct latitude, and to obtain true time very nearly. Its adaptation to the purposes of illustration and instruction in practical astronomy in colleges and schools will occur to every teacher; and it furnishes for the engineer and surveyor an instrument in many respects superior to anything that the writer knows of for general purposes. The graduations of the horizontal limb are perfect, and the two equidistant verniers on the opposite sides of the instrument read precisely the same.

* *Handbook for Surveyors*, by Prof. — Merriman.

The engineer will find the ground-glass shades a great convenience in reading the vernier. They are so placed as not to be readily broken, and they shed a clear, white light upon the graduations.

The diagonal eye-piece will suffice in nearly every case for aligning inclined or vertical shafts in mines.

There is no difficulty in complying with the request of the Surveyor General, namely:—

> Surveyors are expected to observe for azimuth every clear day. With proper care in transmitting the instrument, the levels will seldom get out of adjustment and then the complete observation for azimuth does not require more than 10 minutes, generally it can be done without interfering with the work on the line. The reduction will take about 15 minutes. It is hoped that with the forms and tables supplied to surveyors the work has been made so short and easy that no objection to the frequency of observations should fairly exist.*

Personally, the writer has not a very high opinion of the solar compass, and he would far sooner depend upon an observation for azimuth made with a transit with full vertical circle. Prof. J. B. Johnson in his work on *Surveying* shows that very large errors may result, if observations be taken with the solar compass at any but very favourable times. In the writer's experience, the results obtained by direct observation and subsequent computation are more consistent and satisfactory than those given by any mechanism yet proposed for the use of the engineer and surveyor.

It requires but little practice to get accustomed to the use of an inverting eye-piece, and the brilliancy with which objects appear owing to the amount of light gained by dispensing with two lenses is very marked, in comparison with the results obtained by an erecting eye-piece of the same power; it also allows the field-work to be commenced earlier and continued later.

Prof. Benjamin Smith Lyman, of the Franklin Institute, says that:—

> For establishing grades and measuring vertical angles the vertical circle is not only more correct but more convenient than the gradienter, so commonly attached to American instruments, and, at the same time has the important advantage of much greater simplicity in construction.

If a transit has a full vertical circle, the true vertical angle may be obtained, even if the instrument be out of adjustment, by measuring the angle with the telescope normal and reversed, and taking the mean.

* *Instructions to Dominion Land-surveyors*, page 51.

By using the reversion-level in place of the ordinary single-reading level, it is possible to do good levelling, though the adjustments of the spirit-level and cross-hairs are entirely deranged and the collars of the telescope's standards worn. By first bringing the level-bubble to the centre of its run and taking a reading on the levelling-rod, then, by revolving the telescope 180 degrees, making the bubble again central and taking another reading, the arithmetical mean is the correct result.

The shifting centre-plate, by which after an approximate setting up of the tripod the transit can be immediately brought over the station-mark, and the adjustable or telescopic tripod are a great convenience and time-saving arrangement, especially when making surveys in mines or mountainous districts.

Catalogues issued by manufacturers of surveying-instruments are full of illustrations of such contrivances as solar attachments, curve-rangers, omnimeters, revolving microscopes, spirit-lanterns, gradienters and other attachments for the transit, nearly all the invention of men who have spent very little, if any, time in the field. The writer's experience has been that such appendages are more trouble than they are worth, and the extra money might be better spent upon strengthening the working parts of the instrument. These attachments are neat pieces of workmanship but, together with all other attachments that are not absolutely necessary, should be left to adorn a shelf in the manufacturer's store. A trained engineer and surveyor can, with a good transit with fixed stadia-wires, and a complete vertical circle, obtain more accurate results and in much less time without such mechanical contrivances than he can with them. The most convenient reading-glass for mining surveys is a jeweller's eye-glass, which leaves both hands free for manipulating the clamp and tangent screw, and the best for general outside work is the pocket magnifier, about 1¼ inches in diameter.

Water-power Development Survey.

A cross-country transit and stadia topographical survey about 18 miles long and ¼ mile wide for the location of a canal for water-power purposes cost, including all supplies and the incidental expenses, levels, contours at intervals of 1 foot, stadia work, office-computation, reduction of notes, and the drawing of the final plans, 1s. 4d. (32 cents) per acre.

Instead of having a rod graduated expressly for the stadia-wires, it is much better to have the wires fixed by the maker to cut off 5 feet of the levelling-rod at a distance of 500 feet from the centre of the instrument, which is the mean of most distances measured on good topographical work. The maximum error for distances read between 100 and 1,000 feet will then be about 1 foot.

The following conversion-table is useful:—

Chains into Feet.		Feet into Links.		Links into Feet.	
Chains.	Feet.	Feet.	Links.	Links.	Feet.
0·1	6·6	1·00	1·515	1·00	0·66
0·2	13·2	2·00	3·030	2·00	1·32
0·3	19·8	3·00	4·545	3·00	1·98
0·4	26·4	4·00	6·060	4·00	2·64
0·5	33·0	5·00	7·575	5·00	3·30
0·6	39·6	6·00	9·090	6·00	3·96
0·7	46·2	7·00	10·606	7·00	4·62
0·8	52·8	8·00	12·121	8·00	5·28
0·9	59·4	9·00	13·636	9·00	5·94

By moving the decimal point, this table is much extended: thus 70·0 links are 46·2 feet or 700 links are 462 feet; and 70·0 feet are 106·06 links or 700 feet are 1,060·6 links.

From a number of trials, the rapidity of measuring with a standardized steel-band and a standardized steel-chain, with two skilled chainmen and the mean error in measurement is as follows:—

Instrument.	Mean Speed per Minute.	Mean Error.
Chain ...	66 feet	0·0039 time the square root of the distance measured.
Band ...	74 do.	0·0027 do.

Therefore, the steel-band is nearly one and a half times as accurate as the steel-chain.

The writer has found that a light telephone-wire (well stretched by the linesman) 250 to 500 feet long, is a cheap and excellent substitute for the chain or tape on preliminary surveys. With it, long lines on the prairies may be rapidly measured, as accurately as with a good tape.

Mr. John Barr *versus* The Municipality of Macdonald.

The farm owned by the plaintiff, Mr. John Barr, was located on sections 6 and 7, township 9, range 2 west of the principal meridian. This part of the country is very flat, the natural trend of the land being in a northwesterly direction with an average fall

of about 9 inches to the mile and from the site of the plaintiff's farm there was a rise of about 1½ feet for 1 mile northeastward and 1 mile southwestward. The defendant municipality constructed a road on the western boundary of the plaintiff's farm and in excavating for the road-side ditches, the excavated material was thrown up to form a dump or road-grade in the centre of the road-allowance in the manner usually adopted in prairie-country; the dump, after being levelled, forming a road-grade averaging in height about 18 inches above the level of the prairie. The defendants provided no egress for the water running off the lands to the north, south and east of the plaintiff's farm, either by culverts or cross-ditches; the consequence was that the spring rainfall, instead of running off in a northwesterly direction, was dammed back by the road-grade, and flooded the plaintiff's lands to a depth of about 10 inches. The effect of this was that the plaintiff was unable to seed his land until very late in the spring, which is a very serious matter in this Province, owing to the shortness of the seasons. And afterwards, before the plaintiff's wheat was quite ripe, through further rains the plaintiff's land was again flooded and the greater part of his crop destroyed. The plaintiff therefore sued the municipality in the Supreme Court, claiming heavy damages.

The writer was engaged to make a topographical survey on behalf of the plaintiff, more than ordinary accuracy being demanded, owing to the fact that the municipal authorities denied the plaintiff's allegations and had employed engineers to make a most elaborate survey for them. The writer first of all ran lines of levels establishing stations every 100 feet apart along the road-allowances, around the plaintiff's and adjoining sections. Being, in fact, parallelograms 1 mile square, contours were taken by running lines at right angles, connecting the stations on the eastern and southern boundaries of the sections with the stations immediately opposite on the western and northern boundaries, setting plugs 100 feet apart, thus subdividing the interior of the sections into small parallelograms 100 feet square. Knowing the elevations at each corner, it was thus possible to show by the contour-levels approximately every small difference in altitude. The writer may add that the whole of this work was done with the combined transit and levelling-instrument, and that the angles and levels proved very accurate on the main stations; and, what is more important, the plaintiff won his case.

The telescope is remarkably clear and perfect, and the writer found no difficulty in back-sighting on and bisecting the section corner-posts (iron-bars $\frac{3}{4}$ inch in diameter) at 1 mile, and to bisect the aligning rod (1 inch in diameter) at a distance of $1\frac{1}{2}$ miles. Surveying in the earlier part of the summer over the rich alluvial lands is very trying, as every breath of wind raises clouds of very fine dust from the newly-harrowed and seeded fields; but the centres, telescope and screws were so well protected by the dust and rain-guards that the writer had not the slightest trouble with them.

City-surveys.

In no part of the world is such extreme accuracy and close instrumental work demanded in the direction of lines of survey as is demanded by the Provincial laws for the registration of plans in the Land's Titles Office. In laying out building-lots in the western part of this city, known as the Dominion Government subdivision, the writer had a most severe test of the graduations and telescope of the transit in running around the exterior boundaries of this block, which included thirty-two angles of various degrees with sights varying from 200 to 1,800 feet; all the angles were repeated four times on different parts of the plate, and the measurements were made by a standard steel-tape with a spring-balance and thermometer between the points.

In closing the survey, the writer missed the centre of the iron-bar at the starting point by $1\frac{1}{2}$ inches. In fact, with a transit of this kind having two verniers reading to $\frac{1}{2}$ minutes, a good surveyor should be able to measure easily horizontal angles with a probable error of 1 second, if proper precautions be taken to eliminate systematic and accidental errors.

Bridge-surveys.

When working against time in preparing an estimate for a proposed steel-bridge with masonry-piers on pile-foundations over the Red river, near St. Andrew's rapids, which at this point is about $\frac{1}{2}$ mile wide, the writer made a triangulation-survey of the proposed site from the north end of a base-line, 400 feet long, on the western shore; a right angle was turned off and an iron-bar centred on the eastern shore of the river, where another right angle was turned off and a 400 feet base-line measured and an iron-bar centred. On setting over this iron-bar and again turning

a right angle, the wires cut the iron-bar at the south end of the base-line on the western shore. In this case, also, the angles were repeated four times on different parts of the horizontal plate. The actual precise measurements across the river made with a standard steel-tape, after the river was frozen over this winter, only differed by 1½ inches from the calculated distance.

Mr. H. D. Hoskold (Buenos Ayres) wrote that the "combined transit and levelling instrument for accurate work in general land, city, mine and railroad surveying" recently introduced by Messrs. John Davis & Son, was of a similar type to his (Mr. Hoskold's), miners' transit-theodolite, with a large magnetic compass introduced in 1863, and illustrated in the *Transactions*,* and is evidently intended as a substitute for it.

Various instruments are also constructed in the United States, similar in form to the one described by Mr. Griffith with horizontal circles, 6½ inches in diameter. No doubt it is a very useful instrument for such surveys as those described in the paper, but various other transit-theodolites exist with circles from 5 and 5½ inches in diameter, and one of these could have been employed with equally good results.

The spirit-bubble attached to the outside part of one of the Ys, with its Y on one side, and the second Y on the other, are certainly obstacles to an easy and clear reading of the magnetic needle when it approaches the eastern and western portion of the compass-box; and, for this reason, he (Mr. Hoskold) preferred to place the circular magnetic compass on the top of the telescope, at least for mine-surveying purposes, in which a few magnetic bearings only would be required when the horizontal angles are constantly measured upon the divided circle of a theodolite. Besides, a magnetic compass less in diameter than the one attached to Mr. Griffith's instrument is in the form indicated sufficient for all purposes, and this renders the instrument more compact and less cumbersome; neither is it necessary, except for double verification, scientific or curious purposes, to obtain the magnetic bearing of all the lines which could occur in any given surface-survey for public works.

Levelling by means of the telescope of a theodolite was

* *Trans. Inst. M.E.* 1900, vol. xix., page 238.

practised many years ago. It was mentioned by Mr. Butler Williams in his *Practical Geodesy*, 1842; it was also recommended in his (Mr. Hoskold's) *Practical Treatise on Mine, Land and Railway Surveying*, 1863, and in other more modern works. In order to obtain the greatest facility and accurate results by this system, the spirit-bubble should not, as is the case with the instrument to which Mr. Griffith refers, be placed under the telescope. The covered vertical circle, and part of one of the Ys on one side, and the second Y on the other, impede a quick and certain view of all parts of the spirit-bubble at the same time, and if the bubble is a long one, and its ends project beyond the obstacles referred to, it is not sufficient to be able to inspect first one end and then the other alternately to find out when it is properly level. He, (Mr. Hoskold) had found that it was the best practice to place the long spirit-bubble on the top of the telescope, or on one side of it.

In his (Mr. Hoskold's) civil- and mining-engineer's transit-theodolite, recently introduced, for connecting underground workings to the surface, *vice versa*, and for general surveying,* as in all other superior instruments, a sensitive spirit-bubble is attached to the horizontal arms carrying the verniers to the vertical-circle: so that, supposing the levels on the horizontal circle should be disturbed, the vertical-circle level is independent and for levelling purposes the lower levels on the horizontal circle may be more or less neglected; neither are vertical angles affected by such a disturbance. This spirit-bubble to the vertical-circle is therefore, an important addition, but it has been completely omitted in the instrument referred to in Mr. Griffith's paper. The civil- and mining-engineer's transit-theodolite, previously referred to, has also a long and exceedingly sensitive extra spirit-bubble attached to one side of the telescope: levels can, therefore, be taken with it without reference to any other parts of the instrument, as accurately and in as facile a manner as by a large sized dumpy level. Consequently, the instrument must be considered to be a combined transit and level of superior quality.

It is surprising that Mr. Griffith should allow himself to be guided by prejudice (as he says) instead of judgment in reference to the old-fashioned mode of levelling an instrument with four screws placed between parallel plates. There are various ob-

* *Trans. Inst. M.E.*, 1901, vol. xxii., page 536.

jections to this plan which have been acknowledged for many years past by instrument-makers and engineers. In this old plan of levelling an instrument, the semi-diameter of the parallel plates, from the exterior part of the vertical axis to the centre of the levelling-screws, forms too short a base of resistance to the weight of the overhanging horizontal circles and the upper works resting upon them, and the stress thus introduced is all the greater in proportion to the height of the Ys, the size of the vertical circle, and the length and diameter of the telescope, so that a strain is put upon the vertical axis and the levelling-screws, which latter are frequently made too small. Besides, each pair of levelling-screws pull one against the other, causing tension: also, if the parallel plates are out of parallelism, it requires constant and extra attention to keep them parallel. If they are not exactly so, the levelling of an instrument may be performed all the same with more difficulty; but, in this case, the vertical axis of the instrument would not be in the same vertical plane as the plumb-bob suspended from the underside of the tripod-stand-head, and, consequently, an error would be introduced into the horizontal angles so determined. When anyone comes forward with such considerate and good intentions as those displayed by Mr. Griffith, it is necessary to consider that the doctrine laid down should not only be suitable for any particular locality; but, if it is to be of the greatest service, it must be capable of being applied to any or all localities under varying conditions and circumstances, and from this principle he (Mr. Hoskold) concluded that the "four-screw levelling plan," old system, is more adapted for use in a moderately level camp or field or, better still in street-surveys, than it would be in elevated mountain-regions, where the surface-slopes could form all manner of vertical angles up to 60 or 70 degrees. The complaint of surveyors is that in such awkward places it is difficult to place the tripod-stand over a station and, at the same time keep the horizontal divided circles and parallel plates level, within a reasonable degree and time. For these and other practical reasons, a triangular levelling-base, with three levelling-screws, is attached to all the best modern instruments. The advantages are:—(1) Each arm of the triangular levelling-frame, or base, projects from the centre of the instrument to a perpendicular line let fall from the edge of the horizontal circles, and

when the instrument is heavy, with circles 6½ inches in diameter, a little further, consequently, there is greater resistance of the levelling-screws to the weight of the instrument, giving to it greater stability and rendering vibration impossible. (2) When once the instrument has been levelled, any amount of work may be performed from a given station, in topographical and other operations, without disturbing the levels. And (3), there is a greater facility in levelling up, because when once effected, supposing any little derangement should occur, it is instantly rectified by touching one of the screws with one hand only. This correction, however, cannot be done by the old plan of levelling an instrument, unless by turning two of the screws with two hands; besides this would most likely throw the cross-bubble out of level, requiring a re-adjustment of the other two screws. In the triangular levelling-frame, with three screws, the plumb-bob is suspended from the lower end of the vertical axis, so that if it is out of parallelism with the triangular locking frame screwed to the head of the tripod, the perpendicularity of the vertical axis and the plumb-bob coincides, that is, it is in the same vertical plane. The difficulty connected with the four-screw levelling apparatus is felt still more in underground surveys, where the engineer or surveyor has to carry his book, pencil, lamp, etc., and to manipulate his instrument. The majority of the British, French and Italian instruments sent to South America, Africa, India, Australia and other places, have a triangular levelling-base with three screws attached to them.

In reference to the solar compass, another clumsy apparatus attached to American instruments and noted in the paper, he (Mr. Hoskold) was in accord with the opinion expressed by Mr. Griffith. It was, indeed, surprising that so expensive and uncertain mechanical means should be adopted instead of the simple astronomical problems readily available for determining the true meridian, azimuths, latitude, time and longitude. One of the most facile and accurate modes of finding the true meridian, azimuth, and rate of a timekeeper was described in his (Mr. Hoskold's) discussion upon the paper for finding the true meridian by Mr. A. L. Steavenson.*

In conclusion, he (Mr. Hoskold) desired to express his sense

* *Trans. Inst. M.E.*, 1901. vol. xxi., page 28.

of the great practical value of Mr. Griffith's paper, as it contained experimental points of great service to "the younger members of the profession," for whom Mr. Griffith appeared to have written it.

Mr. JOHN M. LIDDELL (Old Man River, Alberta, Canada) wrote that he had found much need for an instrument capable both of observing angles accurately and of running levels, as it frequently happened in new countries that either work was required, without notice, at outlying places to which several instruments were not easily carried.

The description of stadia-work was very interesting, and he would like to have a description of the arrangement of the hairs and diaphragm, as any disturbance of these from their adjustment would cause excessive trouble. He had seen an old instrument with hair-lines marked on the glass, which secured their position in relation to each other. The magnetic needle was much used in Canada for land-surveys, and the addition of a good needle-dial would be very convenient, if it could be arranged without making the instrument too cumbrous. He had found some trouble from fine adjustments being disturbed by the roughness of local vehicles upon the "trails" of the country, and he desired a safer system of fixing both bubble-tubes and diaphragm. He asked what make of rod or levelling-staff was used for stadia-reading, and he suggested that it be figured on both sides, that is, from the bottom upward on the front and from the top downward on the back, in order that the heavy end might remain on the ground, and the rodman could turn front or back to the observer as required. He supposed that the accidental errors eliminated by so reversing the rod were those of reading the figures only, as an error in the lower line arising from mis-adjustment of the instrument would similarly occur in the upper line, 14 feet above.

Triangular screw-plates (three screws) were, he thought, more liable to permit shaking of the instrument by wind, and also to cause accidents from inadvertence in not securing the binding-plate, when placing the instrument upon the tripod, especially where three tripods were used for a traverse.

In determining the north point, he thought that the polar star was the most satisfactory for use in the observation of the

northern hemisphere and Mr. Arthur Beanlands referred to it especially in a paper which he read some years ago.* It was of course somewhat troublesome to observe in the climate of England; and, for pit-surveys, it was best (he thought) to refer as often as needed to a line beaconed off on the surface, the true bearing of which had been ascertained. In long surveys of a new open country more opportunities of observing the polar star occurred, and no doubt its value for checking and attaching surveys of adjoining areas was evident.

With regard to chains, he would mention a wire-chain of American make, having the number of the links stamped on it in small figures. The chain, several hundred feet in length, was very light and strong, and contributed much to speed and accuracy of measurement in open flat country.

Mr. Griffith's paper was very interesting, and he thought that it illustrated a decided step towards the improvement of surveying-instruments.

The CHAIRMAN (Sir Lindsay Wood, Bart.) proposed a vote of thanks to Mr. Griffith for his paper.

Mr. S. F. WALKER seconded the resolution, which was cordially approved.

Mr. SYDNEY F. WALKER read the second section of his paper on "Alternating Currents and their Possible Application to Mining Operations," as follows:—

* *Trans. Inst. M.E.*, 1895, vol. x., page 57.

ALTERNATING CURRENTS AND THEIR POSSIBLE APPLICATION TO MINING OPERATIONS.

PART II.—HOW ALTERNATING CURRENTS MAY BE USED IN MINING.*

By SYDNEY F. WALKER.

Alternating currents may be used for lighting, heating and power.

I.—Lighting.

Arc lamps, incandescent lamps of all sizes, and the so-called incandescent lamps, which have been worked out by Prof. Nernst, can be worked by alternating currents.

(*a*) *Arc Lamps.*

Arc Lamps.—Arc lamps are of two kinds, open and enclosed. The open arc lamp is arranged to burn freely in the atmosphere, protected only from currents of air by the usual globe, and only so protected because the currents of air which are passing through an arc lamp, which is not protected from them, cause it to burn irregularly. The enclosed arc lamp is arranged to burn with the space between the ends of the carbons, from which the light emanates, enclosed in an atmosphere of carbon-monoxide and carbon-dioxide gases: the consumption of the carbons being very much less than where the arc is exposed to the atmosphere, even when protected by a globe, and the light is much steadier. In both forms of lamp, however, the ends of the carbons are in contact when the lamp is not in use, in all modern forms, and are separated when the current is switched on to the lamp, the arc forming between the separated ends of the carbons, and the light being produced principally by the vaporized carbon which is created at the end of the positive carbon. In each form, also, some arrangement has to be provided for causing the carbons to

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 451.

approach each other, so as to maintain the distance between them constant, as they are burnt away in producing light. In both forms, the arrangement for striking the arc (as it is termed), for separating the carbons, and that for causing the carbons to move towards each other, for feeding (as it is termed), includes some form of electro-magnet, and here one of the early difficulties arose in connection with the use of alternating currents with arc lamps.

Alternating currents do not produce magnetism in the same manner as continuous currents do. The operation of magnetization, as we believe it to be, according to the latest modern theory, consists in the swinging round of the individual molecules of iron, under the influence of the electric current, which is passing round the whole mass of the iron. When the current ceases, the molecules swing back again, nearly into the position which they occupied before the passage of the current, and if a current then passes in the opposite direction, they swing round again, in the direction opposite to that in which they turned under the influence of the first current. The operation of electro-magnets, in which armatures are arranged to move to and fro, when currents pass, or cease to pass, is due to the creation of lines of force, which may be defined as unsatisfied attractions of iron-molecules, in this case passing through the iron-cores of the electro-magnets, and continuing out into the space beyond, where the armatures are situated, causing the molecules of the iron of which the armatures are composed to swing round in the direction of the lines of force, and hence to be attracted to the poles of the electro-magnet, each armature moving as a whole under the influence of the action of the molecules and bringing with it any piece of apparatus to which it is attached.

When the exciting current, the current which creates the magnetism, is alternating in direction some thousands of times a minute, and also constantly changing in strength, the iron-cores of the electro-magnets do not receive any magnetism. For practical purposes, the molecules do not receive any permanent impulse, because the effect of one current is immediately wiped out by the next, the tendency of the molecules to turn in obedience to one current being neutralized by the tendency in an opposite direction. Hence, some special arrangement had to be made, if arc lamps were to work with alternating currents. But the difficulty has been long since overcome by breaking up the masses of iron which are subject to the magnetizing influ-

ence of the electric currents. The iron-cores of the electro-magnets which actuate the mechanism of alternating-current arc lamps are divided up into very small portions, and with that arrangement sufficient magnetism is obtained for all practical purposes.

The Light given by the Arc Lamp when supplied with Alternating Currents.—The next trouble in connection with arc lamps, which are supplied with alternating currents, is the fact that the light given by the lamp is in a different direction from that given by a lamp furnished with continuous currents. As mentioned above, the major portion of the light furnished by an arc lamp comes from the small area of the positive carbon, where the current passes from that carbon into the arc, on its way to the negative carbon. At this point, the carbon undergoes a process of distillation, it is heated up to an enormous temperature, until, in fact, it is vaporized, and in the process of heating it gives out light. Some light is also given out by the glowing carbons on each side of the arc, the short pieces which are heated up close to the arc itself, but the major portion comes from the spot named. In addition to the major portion of the light coming from this spot, the minute crater which is formed on the end of the positive carbon (a small indentation due to the vaporization which is going on, and which forms a very good reflector, as it is glowing at white heat) directs the light downward. That is to say, of the light furnished by an arc lamp, when furnished with continuous currents, nearly the whole is directed below a horizontal line passing through the arc, the largest portion being between two lines making angles of 30 and 60 degrees respectively, with that line. For the great majority of the uses for which the arc lamp is required, this arrangement is very suitable. The light is nearly always wanted below the lamp. But when an arc lamp is supplied with alternating currents, there are two positive carbons, and two negative, each carbon becoming alternately positive and negative in turn, the consequence being that there are two spots from which the light principally emanates, and two small craters, each forming a reflector, one throwing the light upwards, and the other throwing it downwards. The two craters in the ends of the two carbons are each smaller than the one crater in the carbon when con-

tinuous currents are employed. The result is that the light from an alternating-current arc lamp is fairly evenly distributed above and below the horizontal line drawn through the arc, but consequently that thrown down is half approximately of that furnished by a continuous-current arc.

Overcoming this Difficulty.—This difficulty is overcome in three ways, principally:—By placing a reflector above the arc, arranged to throw the upper rays down; by converting the alternating currents either into rectified alternating currents,* or by converting them into continuous currents, by means of an alternating-current motor-generator, or a rotary converter. It may be taken as an axiom, that in whatever form the current is delivered to the electrical engineer, with his present knowledge (if he knows his work, and is allowed to have what apparatus he asks for), he can convert it into any other form that may be required. The writer mentions this fact, in view of the power-generating stations which are being erected in different parts of the country, and which will probably be arranged to supply alternating currents, on account of the ease with which they can be transmitted over long distances. No matter in what form the colliery receives the current, it can be used in what form the engineer likes. This is important, as will be seen later in this paper. If alternating currents are being generated at the colliery, or if they are being delivered to the colliery, they can be rectified, if single-phase, and used for arc lamps, the rectified current answering equally as well as the continuous currents. Or they can be used to drive a motor-generator, or converter, the generator-side of the apparatus furnishing continuous currents of the pressure required. With two- or three-phase currents, the latter arrangement is the only one possible, with the apparatus at present on the market, if it is desired to use continuous currents for the arc lamps, or their equivalent. The rectifier, so far as the writer is aware, has not been adapted for two- or three-phase currents.

Running Arc Lamps from Alternating-current Services.—In addition to the above, arc lamps may be run from alternating-current supply-services, where the question of half the rays of

* *Trans. Inst. M.E.*, 1901, vol. xxi., page 465.

light being thrown upwards is immaterial, or where reflectors above the arc will do all that is required, in the following ways:—

They may be run directly on one circuit, simply in series with each other, just as arc lamps are run from Brush arc-light machines.

Each arc lamp may be run from a transformer, which is arranged to receive its current from the supply-service, at whatever pressure it may work, and to convert the pressure to that required for an arc lamp, namely, 50 volts; and this applies to two- and three-phase services, bearing in mind that with two-phase it is best to have two arcs, one in each phase, and with three-phase, three arcs, so as to keep the circuits balanced.

Where the lamps are run in series also, it can be arranged that an induction pass-by is provided, automatically taking up any surplus pressure which arrives, giving out any pressure required by the lamp, within certain limits, and keeping the circuit complete when the lamp goes out. The arrangement for this purpose is very simple: it consists of a choking-coil, bridged across the terminals of the arc lamp. When the lamp is taking current, the choking coil is only slightly operative; if the arc burns long, the choking coil tends to keep the pressure, absorbed between the terminals of the lamp, constant, by forming a path for the current not used in the lamp and by reducing the pressure by induction; and if it goes out (through, say, the carbons sticking) the choking coil takes up the pressure which was taken by the arc lamp, so that the total pressure required by the service remains approximately constant; when burning, the energy absorbed in the choking coil is very small, approximately equivalent only to that which would be absorbed by a cut-out used with a continuous-current arc lamp.

Alternating-current arc lamps may also be used in connection with services of 100 or 200 volts, singly or in pairs, by using the same devices as are used with continuous-current services. That is to say, the lamp, if it is to burn singly, is connected across the supply-mains, the surplus pressure being taken up by a choking-coil just as it is taken up by a resistance with continuous currents.

(*b*) *Incandescent Lamps and Nernst Lamps.*

Incandescent Lamps.—Both incandescent lamps, as they are known, those in which a fine carbon-filament is enclosed in a

glass globe from which the air has been exhausted, and those known as Nernst lamps, in which a glower of highly refractive material is made to glow in the atmosphere, owe their ability to furnish light to the fact that heat is generated in the filaments, or the glowers, by the passage of electric currents through them. It is immaterial whether the currents are continuous, or alternating, provided that certain rules are observed, namely, that the periodicity or the number of reversals of the current per second is not less than 25 with carbon-filament lamps; and with Nernst lamps probably considerably lower frequencies will answer. The reason of the limitation is as follows:—Each current which passes through a carbon-filament generates a certain quantity of heat, depending upon the square of the current-strength, the resistance of the filament, and the time during which the current is passing. As explained in the first part of the paper, although the current-strength is constantly changing during the cycle through which it passes, the virtual current (as it is termed) which corresponds to the average in other operations, produces the same heating-effect, that is, it delivers the same quantity of heat to the filament in a given time (the time of its period, say $\frac{1}{25}$ or $\frac{1}{40}$ or $\frac{1}{100}$ second) as a continuous current of the same strength as the virtual current represents, would deliver in the same time, the $\frac{1}{25}$, $\frac{1}{40}$ or $\frac{1}{100}$ second. But now another feature of the problem comes in: the temperature, which any body assumes, is dependent upon the rate at which it is receiving heat, its specific heat, and the rate at which it is delivering heat to surrounding bodies. The rate at which it is delivering heat to surrounding bodies depends upon the extent of its surface, the condition of its surface, and the temperature of surrounding bodies. The mass of the filament also has a material effect upon the temperature assumed, and upon the changes of temperature. Thus, a thick filament will be longer in arriving at a certain temperature than a thinner filament, but once having arrived at that temperature, say that at which it gives out light, it is less affected by changes in the strength of the current, which is delivering the heat, than the smaller filament. A striking instance of this is the case of two forms of incandescent lamps, those in which the filament is thin (such as the ordinary lamps of 16 and 32 candlepower), and the large lamps of 100, 200 candlepower and over, where the power which

is driving the dynamo is irregular. Thus with a gas-engine, which has not been fitted with the modern appliances for producing steady running, or with a badly-made splice in a belt, or a very heavy crank in a single horizontal engine; at each explosion, at each passage of the splice over the pulley of the dynamo, and each time the crank falls over from the horizontal position, there is a distinct difference in the speed at which the dynamo is running, a distinct difference in the electrical pressure generated, and with thin filament lamps a distinct wink in the lamps, while with thick filament lamps there is no wink, unless the changes are very large indeed, and very much prolonged. The mass of the larger filament, and the heat that it holds, protects it from feeling the changes which are felt by the smaller filament lamps. The result is that for practical purposes, and for the lamps usually employed, the periodicity of the alternating currents used for generating heat in incandescent lamps must not be less than 25 per second, and the higher the periodicity the less observable is the winking. On the other hand, the lower the periodicity, the lower, other things being the same, is the loss due to the induction of the alternating currents in transmitting power, as explained in the first part of this paper. It will be understood, from what has been said above, that the Nernst lamp, which has a thick glower made of refractory substances similar to those which are used in the Welsbach incandescent gas-mantle, will be less susceptible to changes than the thin carbon filament. On the other hand, there is a peculiar feature about the Nernst lamp, a critical point in its temperature, above which it gives out a brilliant light, and below which it gives out none. This critical point is due to the fact that below a certain temperature the substance of which the glower is made is an insulator, while above that temperature it is a conductor, using the two terms in the sense that an insulator is a substance of very high resistance, while a conductor is one of comparatively low resistance. The Nernst lamp is new at present, and experience is being gained with it almost daily.

Delivering Alternating Currents to Incandescent Lamps.—For the purpose of delivering current to incandescent lamps, the two cables of a single-phase service, or the three cables of a three-phase service, may be treated similarly to the two cables of a continuous-

current service, lamps being bridged across the two cables of the single-phase service, and across and between any two cables of the three-phase service. Thus, calling the three cables of a three-phase service, A, B and C, lamps may be bridged between A and B, between A and C, and between B and C. With a two-phase service, four cables are employed, in two pairs, each pair representing one phase, and the lamps are bridged across either pair. With two- and with three-phase services, the lamps, if they form any appreciable part of the load, should be divided between the two or three circuits, in such a manner that approximately the same current will be passing in each circuit, at all times. It will be understood that, as with continuous-current services, each individual lamp, or any group of lamps, as convenient, may be controlled by its or their own switch.

A Variation of the Arrangement of the Cables for Two- and Three-phase Services.—The ordinary arrangement of distributing cables for three-phase services is three, and for two-phase services four cables, but three-phase services may be worked with four cables if desired, and two-phase services with three cables. In the first part of this paper, the method of connecting the circuits of a three-phase generator was explained. With what is called star winding, it will be remembered the coils of each phase have their inner ends connected together, the outer ends being connected to the terminals from which currents are taken for the supply-service. It will be evident that if a fourth wire be connected to the common junction, a circuit can be made between each of the three wires connected to the three phases, and the fourth wire, and this is sometimes done. But it must be remembered that the pressure between two wires connected to two phases is different from that between any phase and the wire connected to the common junction. The difference is as 1·73 to 1, but so long as this is remembered, and the lamps or motors are purchased for the pressures ruling between the different cables, there should be no difficulty. It is not probable that this arrangement will be made use of in any colliery, as the great desideratum about colliery-working is to avoid complication and confusion, such as this arrangement might lead to; but there may be cases where it would be of service, and for that reason the writer has dealt with it.

With two-phase services, it will also be evident that in each phase, one cable is the lead or outgoing cable, and one the return; and that the two returns can be made into one if desired, connections for lamps then being made between either cable and the return. It should be noticed that the arrangement of connections with two-phase services with three cables, is different from that with three-phase services and three cables. With two-phase service and three cables, connections are made from either of two cables and a third; while with three-phase, connections may be made between any two of the three.

Two-phase apparatus has not been much used in coal-mines so far, three-phase having been adopted in the great majority of cases where alternating-current apparatus has been employed. But when mining engineers expect that electrical engineers will agree upon which is best for mining work, continuous or alternating-current apparatus, the writer would like to remind them that there is yet another matter of controversy. In electrical circles there are two-phase and three-phase men, just as there are continuous-current and alternating-current men. Also the fact that three-phase has gone ahead is almost an accident, just as the adoption of 500 volts was.

Alternating Currents and Charging Accumulators.—Accumulators have not been used to any great extent in coal-mines, but they may be in the future, and there is one direction at any rate in which their use promises well, namely, for portable lamps. The accumulators for these require a pressure of about 6 volts per lamp, when charging, and the practice is now to connect a number of the pairs of cells in series, across the lighting service of the colliery. As the author pointed out in his paper on the subject before the Institution of Electrical Engineers,* this is a bad arrangement, though a cheap one. The best arrangement would be, the provision of a motor-generator, connected to the lighting service, and arranged to furnish currents at 6 volts, the accumulators being connected across the 6 volts service. It will be evident that, with an alternating-current service, this arrangement could be followed, the motor of the motor-generator being arranged for alternating

* "Electrical Miners' Safety-lamps," by Mr. Sydney F. Walker, *Journal of the Institution of Electrical Engineers*, 1901, vol. xxx., page 815.

currents, single-, two- or three-phase, and the generator being arranged for continuous currents at 6 volts.

II.—Heating.

Heating by electricity has not found much favour in collieries, notwithstanding the fact that a colliery manager can have heat delivered at his house under very comfortable conditions, at practically no cost to his owners. The only point with which the present writer has to deal in this connection is the fact that the same laws which he has explained in the earlier portion of this part of the paper apply to heating by electricity, as well as to lighting by electricity. Whatever can be done in the matter of heating by electricity with continuous currents, can be done with alternating currents, provided that the conditions laid down in the course of this paper are observed.

III.—Power.

Power can be transmitted and distributed by single-phase, two-phase or three-phase currents. It had perhaps better be mentioned that any number of phases can be arranged, and the physical conditions for four- and six-phase have been worked out for certain cases, but as all that is necessary can be obtained with three phases, there is no reason for going any farther, and incurring greater complication. It should also be mentioned that the two-phase and the three-phase apparatus came into being because the single-phase apparatus of those days did not lend themselves to the transmission and distribution of power. The single-phase apparatus is the simple alternator, as French electricians call it, the alternator with which we have been familiar for the last fifty years, the alternator which has been at times the saviour of the electrical world, and at other times quite useless. It is the apparatus in which one set of currents rise and fall, and alternate in direction. It requires, as will be remembered, a continuous current to excite its electro-magnets, and therefore any motor which is worked by single-phase alternating currents must necessarily be provided with continuous currents to energize its electro-magnets. But a little consideration will show that this only applies to starting, since, with the usual arrangement of generator and exciter

(which has ruled for some time now), in which the exciter-dynamo is carried on the same framework as the alternator itself, its spindle being in connection with that of the generator, and its armature revolving with the revolving portion of the generator, if a single-phase alternator with its exciter can be got up to speed by any means, it should run as a motor, since its exciter will furnish current for the field magnets, as soon as it is run at a sufficient speed. Some experiments of Prof. Adams of King's College, at one of the lighthouses where there were two alternating-current generators furnished with magnetism by permanent magnets, showed that an alternating-current machine when supplied with current would run as a motor, keeping exactly the same speed as the generator from which the current was received. From these two facts the use of what are called synchronous motors has arisen, alternating-current motors which receive current from an alternating-current supply-service, single-, two- or three-phase, and which will do good work, but with this peculiarity, that they must always run exactly at the same speed as the generator. If from any cause they get out of step with the generator from which they are receiving current, they must stop. It will be remembered that every electric motor, when running, generates an opposing electromotive force, and electric pressure in opposition to that of the current which is driving it. With synchronous alternating-current motors, so long as the opposing pressure created by the motor is in phase, as it is termed, with the current which is causing it to turn, it will keep on turning, and furnishing power in proportion to the product of the virtual pressure and the virtual current supplied to it, multiplied by the power-factor; but immediately it gets out of step, as soon as the pressures do not fit in with those of the current which is driving it, the motor ceases to receive current and stops, and it is necessary to make a fresh start, running the motor up to synchronism. In America, synchronous motors are very largely used in place of main driving-engines, say for driving large works, where the speed must be quite uniform, and the practice is either to have an accumulator at the works, which is charged by current from the exciter-dynamo, and will turn the exciter as a motor, and with it the generator, till it gets up to speed, when starting, after which it is switched off; or to have a small motor of the

asynchronous or inductive type, which will start without any special arrangements, and will run the synchronous apparatus up to speed. Synchronous motors, single-, two- or three-phase, might be used in connection with the power-supply stations, to receive the power, which could then be used for driving continuous-current generators. This is one use that might be made of synchronous motors at collieries. The synchronous motor will only get out of step, as a rule, where the supply is good, from one cause, namely, overloading; and it is therefore of importance, where synchronous motors are employed, to have them of ample power, so that they are not easily overloaded. The reason why synchronous motors will cease to receive current when they get out of step will be seen if the case of overloading is considered. When the motor is running as it should, the opposing pressure is a trifle less than the imposed pressure of the driving current, sufficiently less to allow the driving current to pass through the motor-coils, and this feature holds for the whole of the cycle. If the motor be overloaded, its speed being a trifle less than that of the imposed current, there will be times during the cycle when the opposing pressure is greater than the imposed pressure, owing to the two being at different portions of the cycle, and the motor not only cannot receive current during that period, but will be sending current back into the supply-service.

Asynchronous or Inductive Motors.

Inductive motors are not now confined to two- and three-phase apparatus, single-phase inductive motors being now made, but not of very large power. The principle of all is the same: the motor is virtually a revolving transformer. In the first part of this paper, the stationary transformer was described. It will be remembered that it is an apparatus by means of which alternating currents of, say, high pressure and low current-strength may be converted into currents of low pressure and high strength, and *vice versa*; and it was explained that the increase or decrease in pressure was brought about by the inductive action of the current, and the number of turns in the respective primary and secondary coils on the transformer. In the induction-motor exactly the same thing takes place, but one of the coils is capable of motion, and moves in obedience to the laws of electromagnetic induction, at the same time, in the course of its motion presenting fresh coils to the inductive influence.

The induction-motor consists usually of an outer cylinder, on the inner surface of which coils of wire are fixed, generally laid in slots in the casting of which the cylinder is composed. There are as many sets of coils of wire as there are phases to the service, thus a two-phase motor will have two sets of coils, a three-phase motor three sets, while a single-phase motor has only one running set of coils, a second set being provided for starting

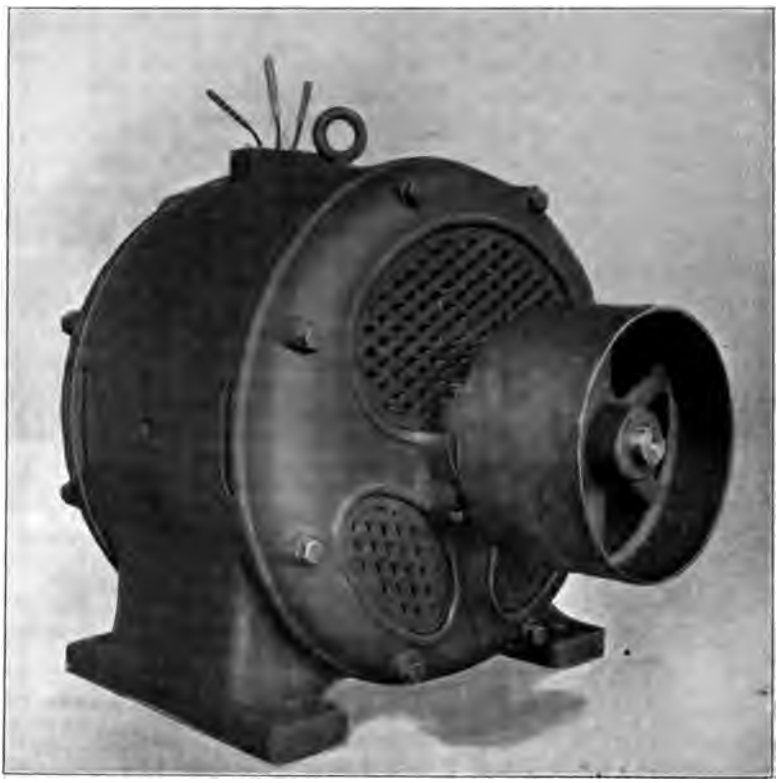


FIG. 39. — WESTINGHOUSE INDUCTION-MOTOR.

it. There are also four, six or more sets of one, two or three coils, corresponding to the number of holes. Inside the cylindrical space enclosed by the stator and its coils, the moving part of the apparatus is fixed. It consists of what is practically an armature, and is very much like the armature of a continuous-current machine, except that it has no commutator. It consists of a drum of iron plates, with slots on their periphery, in

which wire-coils or insulated copper bars are laid. Instead, however, of the wire-coils or copper bars being connected in series, as in the continuous-current armature, they are all connected together at each end by a sort of hoop or in parallel circuit. With wound rotors, in which wound coils are used, one set of the ends of the coils is connected to the starting arrangements, through the slip-rings, as explained lower down. In its simplest

FIG. 40.—STATOR OF WESTINGHOUSE INDUCTION-MOTOR.

form, where copper bars are used, the arrangement is similar to that which would be produced by taking a copper drum and cutting out portions of its surface, so as to leave only longitudinal pieces remaining. The iron core with its windings or bars is mounted on a shaft which runs in bearings carried by an extension of the cylindrical stator-case, or by pillars, or in any convenient way. There is no electric connection between the rotor, as the revolving portion is called, and the stator, as the stationary

portion is called. It will be understood that it has been found necessary to use these terms, as there is no reason why the revolving portion should not receive the currents from the supply-service, and the induction take place in the stationary portion of the apparatus. In place of the squirrel-cage (as the simple form with copper bars is called) being made in the revolving portion, it could quite easily be made in the stationary portion. The usual plan at present is, however, to make the secondary part of the apparatus, the rotating portion. The single-, two- or three-phase currents from the supply-service are delivered to the coils of the stationary part of the apparatus, in the usual arrangement. These currents it will be remembered,

FIG. 41.—ROTOR OF AN INDUCTION-MOTOR.

are rising and falling, and reversing from 25 to 100 times a second, hence, as in the stationary transformer, they induce electric pressures in the coils of the rotor, which is immediately beneath them; and the currents which these induced pressures cause to pass through the coils of the rotor also cause the rotor itself to move in obedience to what are known as the Lenz laws. The rotor having moved a short distance finds fresh conditions due to the currents delivered by the next phase, and moves a little farther, when it finds further conditions tending to cause motion, and so on, the result being that continuous motion of the copper bars or coils with the iron core and shaft, is set up. Another way of describing the way in which motion is given to the rotor, is as follows (it is the explanation which is usually given in the text-books):—The alternating currents, which are

delivered to the stator-coils, create magnetic fields in their immediate neighbourhood, but the magnetic field created by any individual coil immediately dies away and is succeeded by another magnetic field a little removed from the first in space, owing to the current of the first phase having died away and the current of the second phase having arisen. And this goes on continually, a magnetic field being created which is continually moving round the apparatus in the space surrounding it. The coils of the rotor have currents induced in them by this revolving magnetic field, which also create magnetic fields around the rotor; the induced fields follow the field created by the currents

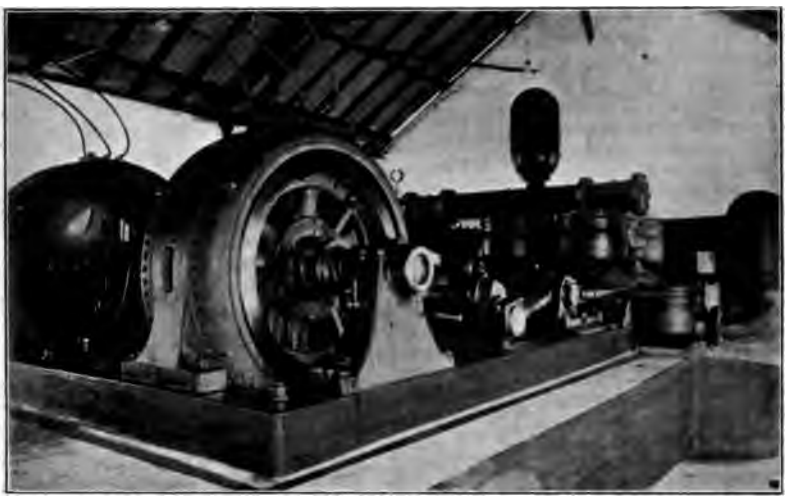


FIG. 42.—THREE-PHASE INDUCTION-MOTORS, OF THE GENERAL ELECTRIC COMPANY OF AMERICA, DRIVING WESTINGHOUSE PUMPS.

supplied to the stator, and the rotor itself moves after the revolving field created by the currents in the stator, and is constantly trying to catch up to it. Hence, the motion of revolution is imparted to the rotor, which may be taken from it to anything which it is required to drive.

The induction-motor is very like the shunt-wound continuous-current motor in its practical application. It will be remembered that the shunt-wound motor runs faster, or more slowly, according as its load is lighter or heavier, and that it is enabled to deal with an increase of load by slightly slowing down so as to allow the additional current to pass through its coils. If there

could be a case where there was absolutely no load on the shunt-wound motor, there would be no current passing at all. The current which is allowed to pass into the motor-coils is due to the difference between the back pressure created by the motor in revolving, and the imposed pressure of the supply-service. Consequently, when an additional load arrives, the motor by slowing down slightly decreases the back pressure, and allows the required additional current to pass through its coils. But the difference in speed in practical work is never large, and the

FIG. 43.—TWO-PHASE WESTINGHOUSE INDUCTION-MOTOR DRIVING AN ENDLESS-ROPE HAULAGE-GEAR.

larger the motor in proportion to its work, the less will that difference be. With the induction-motor, the speed of revolution of the revolving magnetic field corresponds to the imposed pressure with the continuous-current motor, and the difference between the speed of the rotor and that of the revolving field of the stator corresponds to the difference between the imposed pressure and the back pressure with the shunt-wound motor. If there could be absolutely no load, the rotor would revolve at exactly the same speed as the stator-field, and there would be no current taken from the supply-service.

just as with the shunt-motor. And the power taken is due, and in proportion, to the difference between the rate of speed of the revolving field, and that of the rotor. When an additional load arrives, the rotor slightly lowers its speed, and so allows increased slip between the rotor and the revolving field, consequently allowing more current to pass into the coils of the stator. It should be pointed out that, as in the stationary transformer, there is a counter inductive action from the secondary coils to the primary coils. It will be remembered that, when in a stationary transformer, there is little or no load on the secondary coils, no

FIG. 44.—SCHUCKERT THREE-PHASE INDUCTION-MOTOR DRIVING A HAULAGE-GEAR.

current being taken from them, there is a considerable inductive action between them and the primary coils, tending to choke back the current in the primary coils. As lamps are turned on, the inductive action within the secondary coils themselves increases, lessening the inductive action upon the primary coils, and so the primary currents are less choked back, more current passing in consequence. With the induction-motor, the same phenomena take place. The currents in the primary coils in the stator, coming from the supply-service, induce pressures and currents in the coils of the secondary, the rotor, and these affect the currents passing in the primary coils in the same way

as in the stationary transformer. Evidently, the distance between the inducing coils has an important effect in the mutual action. When the secondary coils which are carried by the rotor are close to the primary coils, the effect of the back pressure is felt very much, and the current in the primary coils is choked back. When the distance between the two coils is increased, as say by the rotor slowing down slightly, the inductive effect of the rotor is not so great upon the primary coils, and the primary currents are not so much choked back, more current

FIG. 45.—INDUCTION-MOTOR OF 800 HORSEPOWER AT 180 REVOLUTIONS PER MINUTE, OF THE GENERAL ELECTRIC COMPANY OF AMERICA, WITH FRICTION-CLUTCH, DRIVING A WINDING-GEAR.

passing, and *vice versa*. The apparatus is, as with the shunt-wound motor, practically self-regulating. There is one important difference, however, between the two apparatus. With the shunt-wound motor, it does not matter how much it is slowed down, within certain wide limits, except that it is dangerous for the coils, and that the field created by the armature-current tends to overpower that of the field proper; but, within certain very wide limits, the motor will go on running. With the induction-motor this is not so. An overload of 100 per cent., double its proper load, will cause the slip to become so great that the

machine will practically gradually slow down and stop. This is a valuable property, since it is a safeguard against burning out from over-loading. In some of the earlier tests on induction-motors, it was stated that over-loading to 15 or 20 per cent. was only possible before the motor commenced to slow down. This stage of manufacture has, however, been long since passed, and overloads of 100 per cent. are now possible.

It will be understood that the induction-motor is actually a transformer, in the same sense as the stationary transformer. It transforms the currents delivered to the stator into currents of very much lower pressure and higher strength; and this is another important feature, since the shock from the secondary coil of an induction-motor which is receiving comparatively high pressure, will be comparatively small, and insulation will be much easier.

The induction-motor has also another property in common with the shunt-wound motor. It will be remembered that the shunt-wound motor is reversible: if it is in a position where it may be alternately receiving current for conversion into motive power, and receiving motive power, it will deliver current to the service when it is receiving energy. This is made use of in the electric lifts of the Central London Railway, and when they are descending, they deliver current to the railway, which is used in assisting to run the trains.

The induction-motor will do the same; and if it is in a position where it receives energy, say, when a load is descending an incline, it will generate currents and deliver them to the service.

Starting Induction-motors.—The troubles in connection with the starting of induction-motors are somewhat similar to those in connection with the starting of shunt-wound motors. The resistance of the squirrel-cage rotor being so very small, the currents that will be generated in its coils are so large that they will overpower the currents received from the supply-service, or rather the magnetic field created will overpower the field created by the primary currents, and hence no currents can be received. With small motors this difficulty is not felt, especially where they start without a load, the design of the motors being so arranged that starting is thoroughly practicable. With large motors, however, and even with small motors where the load

to be started against is very heavy (as in driving coal-cutting machines), either the motors must be started light, and clutched on to their work afterwards, or a starting arrangement must be added. The starting arrangement consists of a resistance which is put into the rotor-circuit, when the motor is being started up, just as resistance is put into the armature-circuit of the shunt-wound motor, and gradually cut out as the motor gets up speed. The rotor-coils, in this case, are wound as the armature of a continuous-current machine would be, but all connected at the ends when running normally. In starting, one set of ends is connected to the resistance through the slip-rings. The resist-

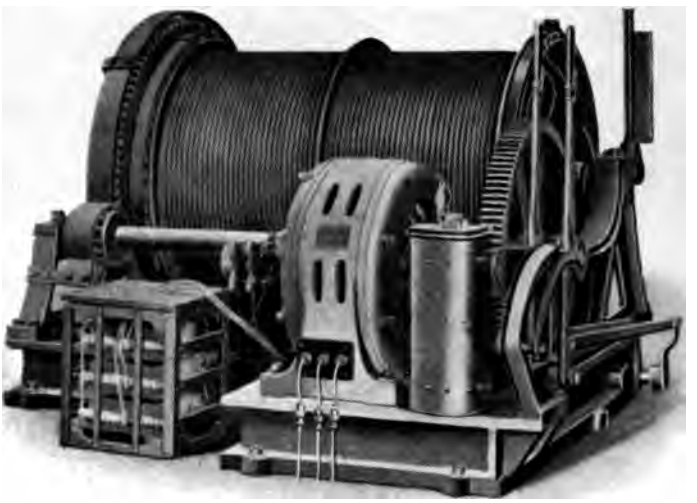


FIG. 46.—INDUCTION-MOTOR, OF THE GENERAL ELECTRIC COMPANY OF AMERICA, DRIVING A WINDING-GEAR.

ance is gradually cut out, as with a continuous-current motor, the rotor coils being finally connected all in parallel, as the last section of the resistance is cut out. The object of the resistance is exactly the same in the two cases, namely, to reduce the current in the rotor and armature-circuits, so that the field created by the currents in those apparatus shall not overpower the field created by the currents supplied by the line.

The Single-phase Motor.—As already indicated, within the last few years the single-phase motor has been worked out on the same lines as two- and three-phase motors, that is to say, without any field-magnets in the ordinary sense, requiring to be

fed with continuous currents. The single-phase motors, which are on the market at present, are constructed similarly to the two- and three-phase motors, but with single-running coils instead of two or three sets, the single coils receiving the single-phase currents and acting upon a squirrel-cage or wound rotor, just as the two- and three-phase currents do. But the single-phase motor will not start with simple single-phase currents. A starting device is necessary, consisting of an arrangement by which the supply-current is split into two, one half of the current being caused to lag behind the other, and this half of the current is taken through a special starting coil, which occupies the same position as the second coil in a two-phase apparatus would do. At starting, the starting device is switched on, also the starting resistance in the rotor - circuit. The latter is gradually switched out, as with other motors, and when the motor is up to speed, the starting coil is switched off. There is one feature however in connection with single-phase induction-motors: they will only start against the load at which they are rated. Thus a 20 horsepower motor will start against a load of 20 horsepower, but not more. If the ordinary work that the motor is to do is 20 horsepower, and if, in addition, there is the inertia of the shafting, belts, pulleys, etc., it will not start. Of course, it is easy to overcome this difficulty by providing a

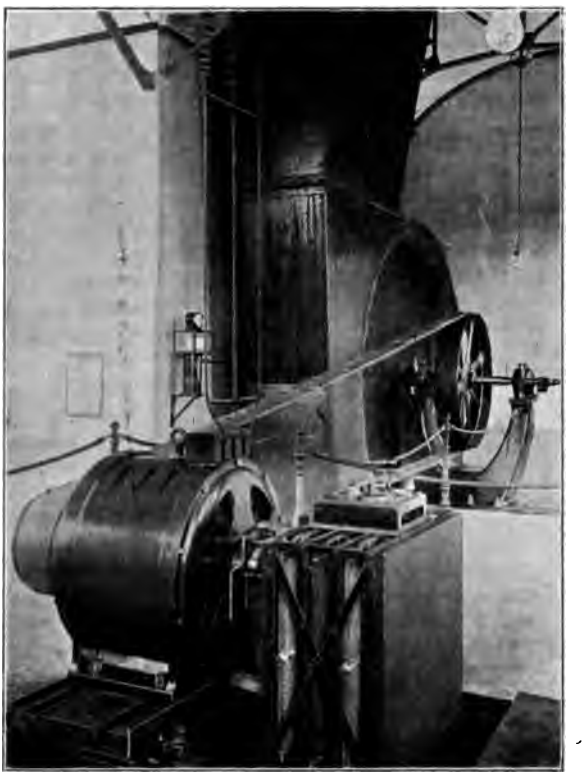


FIG. 47. – SCHUCKERT THREE-PHASE INDUCTION-MOTOR DRIVING A VENTILATING FAN.

motor larger than is necessary for the regular work and large enough to deal with the inertia as well.*

Figs. 39, 40 and 41 show induction-motors and the stator and rotor.

Where Induction-motors can be used about Collieries.—The answer to this is, pretty well in every place where power is wanted. They are in use for winding, pumping, hauling, coal-cutting, and for general work, and are doing well.

Figs 42 to 49 show examples of induction-motors driving different mining apparatus.

FIG. 48.—ELECTRIC LOCOMOTIVE DRIVEN BY A SIEMENS-AND-HALSKE THREE PHASE INDUCTION-MOTOR.

IV.—CABLES FOR ALTERNATE-CURRENT POWER-DISTRIBUTION.

As already mentioned, single-phase currents require two cables, two-phase four cables, and three-phase three cables, but two-phase can be worked with three cables, and three-phase can be worked with four cables. This applies to power-distribution, but only the three cables from the three-phase terminals of a three-phase service should be connected to three-phase motors. The arrangement of four cables described above is for convenience in connecting lamps.

* Since this paper was written, a single-phase motor has been designed for railway work. It consists of a continuous-current machine, with the field-magnet poles laminated, and the armature fitted with a commutator at one end and slip-rings at the other, the slip-rings being connected to points in the armature-winding.

In all cases, the cables should be placed as close together as possible, and no single cable carrying an alternating current should be armoured, nor be enclosed in an iron-pipe by itself. If armouring is desired, the two, three or four cables must be made into one cable and armoured outside; and this applies also to iron pipes: the whole of the cables must be enclosed in one pipe. The reason is, that with separate armoured cables, or with single cables enclosed in iron pipes, the inductive effect of the currents upon the enclosing armour or pipe will be so serious that there will be a considerable loss of energy and of pressure. For overhead work, the wires should be kept as close together as possible.

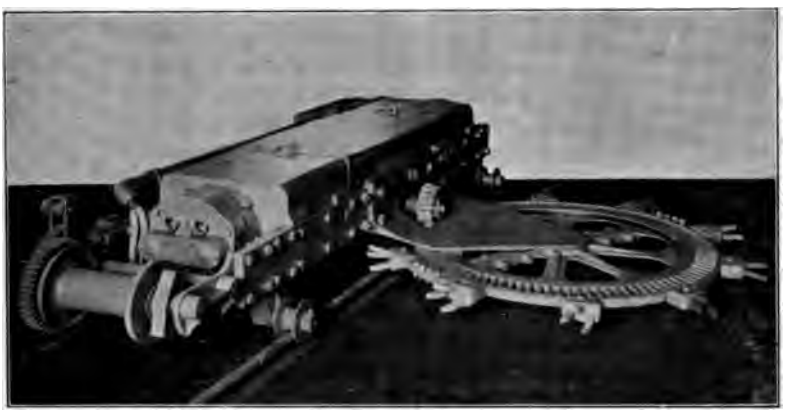


FIG. 49.—DIAMOND COAL-CUTTING MACHINE DRIVEN BY TWO THREE-PHASE MOTORS.

V.—MOTOR-GENERATORS AND CONVERTERS.

These are two forms of apparatus designed to perform the same office, namely:—To convert alternating currents into continuous or *vice versa*. The motor-generator consists of two distinct machines, a motor which is arranged to run with alternating currents where it is desired to convert from alternating to continuous, and a generator which will furnish continuous currents when run at a certain speed. Fig. 50 shows a motor generator. The shafts of the two machines are connected mechanically, and the conversion desired is obtained by calculation.

The rotary converter performs the same operations, but in one machine. The machine is constructed like an ordinary multipolar continuous-current dynamo, but it has in addition to the

segmental commutator, two, three or four collecting rings at the other end of the armature, which are connected to two, three or four points on the armature-coils. When the machine is fed with alternating currents, continuous currents may be taken from the commutator at the other side, and *vice versa*. Fig. 51 shows a rotary converter. But with this apparatus there is no change possible, as with the motor-generator. The conversion is constant. With a motor-generator, both sides of the apparatus can be regulated as desired, and the speed of the motor can be altered as that of any motor is altered. But with the rotary converter, the conversion is once and for all.

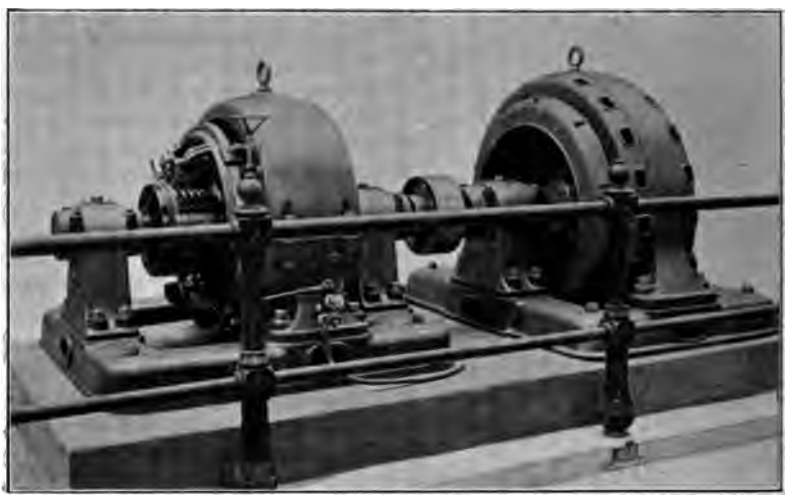


FIG. 50.—MOTOR-GENERATOR FOR CONVERTING THREE PHASE TO CONTINUOUS CURRENT, AND *VICE-VERSA*, OF THE LANCASHIRE DYNAMO COMPANY.

VI.—THE SPEED OF INDUCTION-MOTORS.

The speed at which any induction-motor runs is made up of the speed at which the magnetic field rotates and the number of poles in the stator. The problem is exactly the same as with the alternating-current generator. With the latter, it will be remembered the number of cycles per minute are obtained by multiplying together the number of pairs of poles and the number of revolutions per minute, for single-phase, and correspondingly for two- and three-phase. With induction-motors, the speed of the motor is obtained in much the same

way. This leads to the consideration of the regulation of the speed of induction-motors. Though the speed of an induction-motor varies with the load, in order to allow of more or less current passing, the difference between the speed at full load and at no load is very small, usually not more than 4 per cent.

To obtain further regulation, different devices have been arranged. The most favourite device is altering the number of poles, groups of coils in the stator, or the part of the apparatus

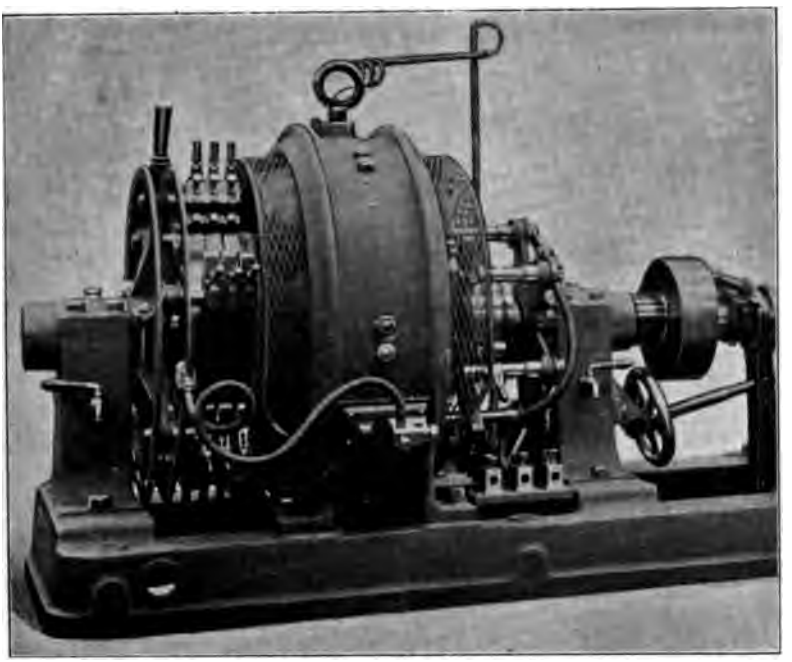


FIG. 51.—ROTARY CONVERTOR OF THE ELECTRIC CONSTRUCTION COMPANY, LIMITED.

which is receiving the currents from the supply-service. By a simple switch-arrangement the number of poles can be altered from say eight to four, and to two, and back again. In connection with this, a German firm have worked out an arrangement in which the rotor is made longer than usual, or two or more rotors are carried on one shaft, the different rotors revolving within different polar spaces in different stators: all, however, being part of one machine, and on the same bed-plate. Any particular speed is obtained by running the motor, the poles

of which correspond to that speed, the other rotors acting as fly-wheels. At starting also all are coupled in parallel, so that there is at starting a good useful pull. A certain amount of regulation is moreover obtainable by inserting resistance in the rotor- or stator-circuits; but this method is, of course, very wasteful.

Mr. Roslyn Holiday (Ackton Hall Colliery) understood that the writer of the paper said that, with an overload of 15 to 20 per cent., the slipping would be so great that the machine would eventually receive no current and would stop. In his own experience an excessive overload would burn up the machine.

Mr. Herbert A. Jones (Bradford) asked whether the writer could give any information with reference to the efficiency of variable three-phase motors. There were two or three motors, made in Germany, of this type, and he believed that another was made in Switzerland, but the efficiency varied very much with the varying speeds; further, the switching gear for the various speeds was complicated, and the first cost of the variable-speed motor was much higher than the fixed-speed motor.

Mr. G. S. Corlett (Wigan) said that, so far as he was able to judge from considerable experience of three-phase work, there was not much opening in mining work for synchronous motors. In addition to the difficulty of starting, he thought that the induction-motor in practice would be found to have advantages identical with those of the synchronous. In one case, the speed was constant, and in the other it was variable; with the smallest practicable non-synchronous motor the maximum speed-variation was only 7 per cent., and with large motors it was reduced to 3 per cent. He did not know of any colliery-work in which a variation of 3 per cent. in speed would be any great detriment. Allusion was made to the arrangement as being unnecessarily complicated for lighting from three-phase wires and the neutral point of the generator, but he (Mr. Corlett) failed to see that there was any complication. Several collieries had adopted a pressure of 440 volts for three-phase power service, and this divided by the square root of 3 (1·73) gave 250 volts, which was the available pressure between the neutral point and the three-phase wires. Consequently, no transforming arrangements

were necessary, and the only complication was an additional omnibus-bar on the switchboard, which was not a very serious matter. Reference was made in the paper to variable-speed motors, and it must be admitted that one of the objections to three-phase machinery was that there was some difficulty in economically obtaining a permanent speed-variation; if a motor running at 600 revolutions was required for a considerable time to run at 500 revolutions per minute, it would be somewhat difficult to arrange. With all motors (continuous or alternating) there was a loss of power momentarily at the time of starting, but the loss only endured for a few seconds. He did not think that the conditions of three-phase current were at all worse than those of continuous current.

Mr. T. H. Bailey (Birmingham) understood the writer of the paper to state that the synchronous motor must always run at practically the same speed. Was not the word "speed" used erroneously for "periodicity?"

Mr. William Hay (Shirebrook) asked what margin of power was required in the engine to overcome the starting of three-phase motors without load. He had an engine of 200 horsepower, a generator of 100 horsepower and an underground motor of 100 horsepower, and 185 horsepower was required to start the underground motor. With this exception, the plant had run 18 hours a day for nearly 2 years without giving the slightest trouble.

Mr. F. Brown (Walsall) said that he did not know whether, in discussing the present paper, he would be in order in advocating the use of continuous in preference to alternating current. The distances in most collieries were not very great, and engineers might thoroughly consider whether it was worth while to save the little money in capital outlay on cables, for the sake of overcoming the disadvantages attendant on the use of continuous current. There had hitherto been an idea that commutators gave trouble, but this was being dispelled, and as regards sparking, of course any motor should only be used in such a position that there would be no danger. With reference to the running of arc lamps, he had found considerable mechanical difficulty as well as electrical troubles; a low

periodicity put constant shocks on the lamps, and therefore alternating-current lamps could not have so long a life as continuous-current ones. With the alternating current there was, as had been mentioned, the immense power required to start the unloaded motor, and the speed was difficult to alter. A pressure of 400 volts had been mentioned as safe, but there was a point where the question of safety must be placed against that of cost, and he thought that it was desirable to spend a few pounds in copper and run the plant at a lower voltage.

Mr. HERBERT A. JONES (Bradford) asked whether Mr. Walker would include, in his reply, the question of the starting current taken by three-phase motors fitted with slip-rings and those without.

Mr. SYDNEY F. WALKER, replying to the discussion, stated that motors were wisely undervalued (as it were) by their makers, and would bear a larger overload than their apparent rating showed. The question of the burning with a certain overload depended on the construction: one motor would burn with a small overload, and another would withstand a heavy one. Mr. Corlett considered that there was no opening for synchronous motors in coal-mines, and that was the impression given in the paper, but they could conceive a case where a considerable amount of power was to be distributed in various ways about a colliery, when it might be convenient to use a synchronous motor. Such motors were largely used in America, where there were large water-power supplies, and where the current was taken at high voltages for long distances. Mr. Corlett would agree that although to-day they did not see much use for synchronous motors, they might do so to-morrow, for during the last thirty years they had seen a great deal that was condemned one day as useless, afterwards brought into general use owing to some trifling alteration. With regard to the stringing of lamps from three-phase cables to a neutral wire, this was a question for the convenience of the colliery-manager; provided that he did not object to four wires, and could be sure that mistakes would not be made by connecting 250 volts leads across a 440 volts service. Mr. Corlett also thought that there were not many cases in mines where it was necessary to vary the speed, but this was desirable in the case of motors for pumps, for instance, and motors for

main-and-tail haulage, etc. There were many cases, of course, where approximately-uniform speeds could be used, and, therefore, non-synchronous motors would be applicable, but there were also many cases in which a varying speed was necessary. With regard to the question of speed or periodicity; "periodicity" was the correct term, but probably it would be better still to say "speed of current." As regarded the amount of power taken to overcome the starting-load with a machine running light, without the load, gearing often absorbed more power than one supposed; but a motor might be constructed, within certain limits, so as to start with whatever current they liked. As there was 200 horsepower, he supposed that the motor, in question, was constructed so as to start in the most convenient way, under the impression that the loss in power did not matter, as it was only temporary. Possibly matters were simplified, and made a little stronger than they would otherwise have been. This was one of the points where the induction-motor was similar to the shunt-wound motor; they had a rush of current very much in the same way that they had in the shunt-wound, and they had the induced magnetic field tending to overpower the other. Mr. Brown had asked about the use of alternating current over long distances, and mentioned that he thought continuous current was safer for use. His (Mr. Walker's) view was that, in some cases where the distance was long and the power to be delivered was great, the difference in the cost of cable alone was such that mine-managers would not be at liberty to spend the amount required, unless it were absolutely necessary; he knew one instance where the cost of cables, with continuous current would amount to £6,000 more than with alternating current in an installation of 1,000 horsepower. An alternating current, with high tension, could be made much safer than continuous current at 500 volts. The high-tension cable should be enclosed, where it was perfectly safe from being touched, and the current transformed down to, say, 100 volts, for use in the motor. There was no absolutely-safe voltage: in Warwickshire, a man was killed by a continuous current at a pressure of 480 volts; in another case, at Fulham Baths, a death resulted from 200 volts; and he believed that a case was recorded of 100 volts proving fatal. Several factors entered into the problem:—High tension was naturally more dangerous, the

amount of current passing through a man was also of considerable importance, but the most important consideration was that of time. In the case at Fulham Baths, 200 volts were passing through the men for several minutes; and 480 volts, at Exhall, for at least 10 minutes. On the other hand, there was a reported case from Austria, where a man was exposed to 5,500 volts for 5 minutes without being killed. He was burnt, and that so quickly that the current was blocked back. As regards the starting of three-phase motors, with slip-rings, and without, they could be made practically what they liked; it was a question of construction and design, within certain rather wide limits.

The CHAIRMAN (Sir Lindsay Wood, Bart.) proposed a vote of thanks to Mr. Walker for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. E. B. WAIN proposed a vote of thanks to Sir Lindsay Wood for presiding over the section.

Mr. F. W. HURD seconded the motion, which was cordially approved.

Mr. H. B. NASH (Barnsley) moved that the thanks of the members be accorded to the President and Council of University College, Nottingham, who had kindly placed their rooms at the service of the members; to the owners of the various works which had been thrown open for inspection; and to the committee of the Midland Counties Institution of Engineers for making such excellent arrangements for the meeting.

Mr. A. M. HENSHAW seconded the resolution, which was cordially adopted

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Mr. MAURICE DEACON moved that a vote of thanks be given to Mr. James C. Cadman for his services in the chair.

Mr. ARTHUR SOPWITH seconded the resolution, which was unanimously adopted.

The following notes record some of the features of interest seen by the visitors to collieries, works, etc., which were, by kind permission of the owners, open for inspection during the course of the Nottingham meeting on September 2nd, 3rd and 4th, 1903:—

CLAY CROSS COMPANY'S IRONWORKS AND FOUNDRY.

Ironworks.—The ironworks comprize three furnaces, 60 feet high, with boshes 17½ feet in diameter. The furnaces are automatically charged, and have bell-tops. Only two out of the three furnaces are at present in blast, and the normal make of the two furnaces is 500 tons per week.

There are eight calcining kilns. The iron-ore on arrival from the ironstone-mines is all directly placed into the calcining kilns. There is also a large coke-bin, capable of holding 250 tons, and the coke is directly conveyed from the bee-hive coke-ovens to this bin.

There are nine boilers fired with the waste-gases from the furnaces, as also are the stoves, ten in number, and of the ordinary brick type, 17 feet high and 9½ feet wide.

The blowing-plant consists of two vertical blowing-engines, having steam-cylinders, 28½ inches in diameter by 6 feet stroke; and two blowing-cylinders, 6 feet in diameter by 6 feet stroke. The usual blowing pressure is 4 pounds per square inch. There is a large surface-condenser in connection with the blowing-engines. The steam is supplied from the range of boilers fired by the waste-gases above mentioned. An economizer, having 440 tubes, is used for heating the water: the average temperature of the water entering the boilers being 280° Fahr. There is also an auxiliary gas blowing-engine worked by the waste-gases from the furnaces. The cylinders are 27 inches in diameter by 30 inches stroke, and the blowing-cylinder is 72 inches in diameter by 28 inches stroke. The gases pass from the furnaces along an underground-flue, through a cleanser, into a gas-holder, and thence into the cylinders. The engine makes about 120 revolutions per minute.

Foundry.—The foundry consists of 8 pits for making vertically cast-iron pipes, from 2 to 36 inches in diameter. Each pit

is fitted with a hydraulic crane. The remaining part of the foundry is a jobbing-shop, and there are also inclined pipe-beds. The foundry is supplied by two cupolas, and the pipes, after being manufactured, are rolled out into the yard for testing and coating purposes, and thence loaded direct into railway-wagons.

The hydraulic power is supplied by a pair of automatic pumping-engines, with cylinders 14 inches in diameter by 18 inches stroke, the pumps being 3§ inches in diameter by 18 inches stroke. A smaller auxiliary hydraulic pump is kept as a reserve. Adjacent to this foundry is another foundry, consisting of pipe-beds used for the manufacture of economizer-tubes and for all castings in connection with economizers.

Economizer.—The castings, after being made and fettled, are conveyed to the economizer-shop, a large corrugated-iron building, containing all the special machinery requisite for the manufacture of fuel-economizers, including boring, rhymering, facing, turning, and other special tools.

The engine for these shops is supplied with steam from a Cornish boiler, placed immediately outside the building. A small economizer, with 48 tubes, is fixed to this boiler, and raises the water to a temperature of 280° Fahr.

CRESWELL COLLIERY.

Creswell colliery, belonging to the Bolsover Colliery Company, Limited, is sunk to the Top Hard or Barnsley seam at a depth of 1,335 feet. The seam dips eastward, at about an average gradient of 1 in 26. The shafts, 18 feet in diameter, are each tubbed to a depth of 375 feet.

No. 1 or Downcast Shaft.—This shaft is fitted up to wind 2,500 tons per day in 9 hours. The cages are double-decked, carrying 6 tubs of 12 cwts. each. Eight rope-guides are used, three being attached to each cage, with two dummy guides in the centre.

The winding-engine has two cylinders, each 40 inches in diameter by 7 feet stroke, with a slightly-tapered drum, 21 to 23 feet in diameter. The speed is controlled by the Thornewill-Davis cut-off gear.

No. 2 or Upcast Shaft.—This shaft is arranged to draw 900 tons per day, and has single-deck cages carrying three tubs of 12 cwts. each. The wire-rope conductors are arranged exactly as at the downcast shaft.

The winding-engine, with two cylinders, each 25 inches in diameter by 4 feet stroke, and a drum, 11 feet in diameter, is fitted with Eatoch slide-valves.

Banking and Screening Plant.—The coal is banked at two levels simultaneously, and tipped at one level by three mechanical through tipplers. The empty tubs are returned to the back of the shaft by creepers and gravity inclines. From the tipplers, the coal is placed upon jigging-screens, where the large coal is taken out and away by three main picking-belts, each 105 feet long. The small coal falls upon two cross-belts, and is again passed over jigging-screens, divided into four qualities, and cleaned on separate belts, each 74 feet long. The picking-belts are fitted, at the loading end, with short belts, which can be lowered into the trucks to prevent breakage of the coal.

Ventilating Plant.—This plant comprizes a Walker compound engine, with a high-pressure cylinder, 18 inches in diameter, and a low-pressure cylinder, 32 inches in diameter, by 3½ feet stroke. The fan, 20 feet in diameter and 6 feet wide, is driven from the engine by 9 ropes, and produces 200,000 cubic feet of air per minute at a water-gauge of 3 inches.

Boiler-house.—There are 10 Lancashire boilers, 30 feet long by 8 feet in diameter, working at a pressure of 100 pounds to the square inch, fitted with Proctor coking stokers, and supplied with coal direct from the screens by means of a creeper and an elevator. There is a Cameron and a Worthington feed-pump.

Electric Engine-house.—The power-plant consists of a six-pole compound-wound direct-current generator with an output

of 180 ampères at 600 volts, when running at 600 revolutions per minute. It is driven by an engine with a cylinder 16 inches in diameter by 4 feet stroke.

A combined lighting-and-power plant consists of two generators; for lighting purposes, a compound-wound generator, with an output of 100 ampères at 200 volts; and for power, a series-wound generator, giving 400 volts at 21 ampères. This set is driven by an engine, with two cylinders 14 inches in diameter by 2 feet stroke.

There is also plant for street-lighting, consisting of a high-speed vertical engine and four-pole compound-wound generator, giving 180 ampères at 250 volts, at a speed of 940 revolutions per minute.

Lamp-cabin.—The lamp-cabin is arranged for 1,500 Protector safety-lamps, lit electrically, and is fitted with two cleaning-machines.

Underground.—The coal is worked on the longwall system throughout, all roads being made in the goaf, outside the shaft-pillars.

The endless-rope haulage is driven by a motor of 160 horse-power, and there are also two other motors of 80 horsepower and 20 horsepower respectively, drawing coal out of dip-workings by means of main ropes. On the rise side, the coal is jigged down to the main levels, and thence it is taken to the pit-bottom by endless ropes.

There is an interesting colliery-village, consisting of 280 houses for workmen, officials' houses, club-house, co-operative stores, and drill-hall.

SHERWOOD AND GLAPWELL COLLIERIES.

These collieries are described in papers written by Mr. J. W. Fryar* and Mr. M. Deacon.†

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* *Trans. Inst. M.E.*, 1904, vol. xxvi., page 475. † *Ibid.*, page 512.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

ANKYLOSTOMIASIS.

Ankylostomiasis : a Forewarning. *By* WALTER C. C. PAKES. *The Journal of the Chemical, Metallurgical and Mining Society of South Africa*, 1904, *vol. iv. pages* 256-260.

Ankylostomiasis has in times past received different names, which to some extent show the sometimes peculiar distribution of the malady. For instance, it has been called " miners' anæmia," " tunnel-sickness," " brick-makers' disease," " Egyptian chlorosis," and (from the alternative name of the parasite) " uncinariasis."

This disease is by no means a new one, for Sandwith has shown, from an ancient Egyptian papyrus, that it was known 3,450 years ago; although in those days the then medicine-men ascribed the worms to the disease, and not the disease to the worms. No mention of the disease appears in medical writings between that date and 1648, when it was described in Brazil, and in the beginning of the eighteenth century, when it was recognized in Guiana. Only in 1841 did Dubini of Milan settle the parasitic nature of the disease. Pruner, in 1847, and Griesinger, in 1851, found the worms frequently in the dejecta of Egyptians, and in 1854 the latter and Bilharz showed the connection between this parasite and " Egyptian chlorosis." It was not, however, until the St. Gothard epidemic in 1880 that the disease was generally known, and the modern knowledge upon the subject dates from then. Since that date the disease has been found to exist almost throughout the known world, between 51° north latitude and 30° south latitude. It has been met with in Burmah, Ceylon, India, Assam, Malaya, Cochin China, China, Japan, Borneo, the West Indies, British Central Africa, Lagos, the Cape, and recent epidemics have occurred in England, Westphalia and Belgium.

It is quite evident, therefore, that from its geographical position, the Rand is not exempt. Further, when it is remembered that miners are drawn from all over the world and that it is known that the British Central African natives are often infected, there is no doubt of the possibility of the importation of this disease on the Rand. Take the British Central African natives alone; Daniells examined the dejecta of 251 natives, and found the eggs of the worm in 25, that is, 10 per cent. of the natives. As will be seen later, one person containing one impregnated female worm may carry sufficient ova to infect a whole community. The natives examined came from the Shiré, Angoni and M'langi Highlands, from Nyasa, and from both the Upper and Lower Shiré rivers.

In view of future possibilities, it is interesting to note that Preston Maxwell has found the worm common among the agriculturists of Southern China.

Lastly, Looss has shown that dogs may act as hosts for the parasites.

Briefly, the disease is one which is characterized by a progressive anæmia associated with irritation of the internal lining of the intestine, particularly of the second portion thereof. The symptoms are those of anæmia, together with those arising from the irritation of the worm. The anæmia is evidenced by pallor, breathlessness, dizziness, swelling of the feet, fainting, and so on, the symptoms, of course, varying with the degree of anæmia. The irritation of the intestine is evidenced by the pain over the stomach, ravenous and perverted appetite, and occasional hæmorrhage. Despite all the symptoms, the sufferer frequently does not waste if his food is plentiful; but, despite the plentiful food, he shows extreme pallor. More will be said of the symptoms later.

Whatever may be the predisposing causes of this disease, the one single causal factor is a nematode worm, to which various names have been given. It is known generally now as the *ankylostoma duodenale* (but has been called severally the *dochmius duodenalis*, *ankylostomum duodenale*, and *uncinaria duodenalis*). Being nematodes, that is, round or cylindrical worms, both sexes are represented. The adult female worm is about ½ inch long and tapers; at the extreme end it is conical and bears a spine. The adult male worm is rather shorter than the female and has a very characteristic and unique caudal appendage. This consists of a large umbrella-like trilobed bursa or sac having eleven ribs, and from the cloaca at the bottom of the sac two long delicate spicules protrude. Thus an adult male is distinguished with ease and certainty. Both worms have a circular mouth supported on a tapering neck, which is furnished at the margin with four strong claw-like hooks, and two conical teeth. The anus in the male is terminal, and in the female subterminal. The vaginal orifice is situated at the junction of the middle and posterior thirds of the worm.

The life-cycle of the worm is as complicated as it is interesting. The impregnated female worm produces a prodigious and never-ending stream of ova or eggs. These eggs measure about $\frac{1}{400}$ inch by $\frac{1}{700}$ inch; they have a regular oval form, with a delicate and beautifully transparent shell, through which the yolk may be clearly seen, often distinctly segmented. In the intestinal canal of the host the ovum does not undergo further development. In the decomposing dejecta of a person harbouring this parasite, the whole process of hatching may be observed. The segmentation increases until a morula or mulberry-form is seen, and, finally, the embryo in the shell. The shell then bursts, and the embryo is set free. When newly hatched the free rhabdite form measures about $\frac{1}{11\frac{1}{2}}$ inch in length and $\frac{1}{2000}$ inch in thickness.

When hatched, there is little to be seen of the internal structure except an intestine and œsophageal bulb. When kept at a temperature of 70° Fahr. in the dejecta, the worms grow about three times their original size in 48 hours, and during this time undergo about four moults. From now onwards the environment appears to determine which of two cycles the larva will adopt:—

(1) If at this stage the larva is introduced into the body of a suitable host, it develops into the sexually-mature adult worm, and the cycle is repeated. There seems evidence that if at this stage the dejecta or soil are partly desiccated, the young larva remains dormant for many months until a remoistening of the medium starts it once more into activity.

(2) If it remains in the moist dejecta it undergoes further moults, until after the lapse of from four days to a fortnight or so (according chiefly to the temperature), it becomes a sexually-mature free rhabdite. In this condition the male measures $\frac{1}{38}$ inch by $\frac{1}{1000}$ inch, and grows to $\frac{1}{24}$ inch by $\frac{1}{300}$ inch. The female may attain a size of $\frac{1}{15}$ inch by $\frac{1}{200}$ inch. After impregnation, the female in the free state probably lays a number of eggs somewhat similar to that produced by the parasitic worm. These eggs develop into free larvæ and adult free worms, and the cycle goes on until the environment is unfavourable, when the cycle is suspended. Whether these free forms are derived from the parasitic form directly, or from the free forms developed from the parasitic forms, does not seem to affect their potentiality for evil. To quote Giles: "The progeny of both develop into parasites or rhabdites, according to the environment in which they find themselves."

The length of time that they exist depends upon the suitability of the environment. Giles has succeeded in reviving the free-stage worms which were in the soil, and which had stood the desiccation of a Punjaub summer, even after the lapse of twelve months. Thus it will be seen that under unfavourable conditions, such as desiccated soil, the rhabdites can exist for many months in a dormant condition. Under favourable conditions they multiply enormously.

The conditions favourable to their development in the free form are moist, warm, organically-contaminated soil. This fact will explain how the disease has acquired two of its names, namely, "brickmakers' disease" and "tunnel-sickness," and will indicate the reasonableness of the term "miners' anæmia."

Giles, who has very carefully studied their extra-corporeal development, makes the emphatic statement that in ordinary water they not only do not develop, but slowly die for want of nourishment; further, he says that the water must be practically stagnant sewage to allow them to develop. This does not mean, however, that the infection cannot be carried by means of foul water, because, as he points out, the rhabdite dies out slowly; and it is quite possible for a rhabdite to be transferred by means of infected water to the intestinal canal, and even though it is slowly dying, the transfer to a suitable environment may result in its resuscitation.

Whether a particular free-form is capable of becoming parasitic appears to depend upon the age of the rhabdite; if it is sexually mature as a free worm, it is probable, from the evidence at hand, that it cannot become parasitic, but so long as it is in the sexually immature form it is capable of developing into the parasitic form.

The method of transfer to the human subject is obvious. The ground or mud is infected by human dejecta—a single dejection may contain thousands of eggs—a brickmaker or miner handles the soil, and carries infection into his intestinal canal while partaking of his food. In a mine, the boots and clothes collect the rhabdite-infected mud; from these to the hands is but a short distance, and from the hands to the mouth an equally short journey.

There is, however, another method of infection, namely, by the skin, chiefly through the hair-follicles. This method of infection was accidentally discovered by Looss, who was studying the worms, and who infected himself in this manner. It has been subsequently confirmed by Sandwith and others. What happens to the embryo when it has entered the skin, and whether it reaches the intestinal canal is unknown, but the fact has considerable bearing upon one of the symptoms which will be explained subsequently.

Arrived in the mouth, the young rhabdite quickly develops into the adult parasitic worm, and attaches itself to the coat of the intestinal canal by means of its powerful hooks. Fortunately, perhaps, as has been seen, the worm cannot produce other worms in the intestinal canal; the eggs must be hatched outside the body and produce the rhabdite form. In consequence, every adult worm present in the intestinal canal must have been ingested as the free form. This, as we shall see, is an important fact concerning the prevention of the disease. The possibilities of infection are, however, enormous. Suppose one person infected with ankylostomes were working in a mine where sanitary arrangements are not quite ideal, where the dejecta-infected soil is constantly moist, and where the temperature is 70° Fahr.; such a man might have twenty adult females, laying 500,000 eggs in the course of a few weeks. If 1 per cent. of these eggs hatched, we might expect 2,500 rhabdites of each sex. If we imagine that a small percentage of these become sexually mature in a fortnight, and reproduce, we shall get a geometrical progression, until in a few months there are millions of rhabdites in the mine. To this add the probability that other miners are infected, and the amount of *materies morbi* becomes truly appalling. Probably 10 per cent. of the British Central African natives, and a certain percentage of Chinese have ankylostomes in their systems, consequently the possibilities of the infection of some of the Rand mines are not altogether negligible.

The next point to be considered is, when does a healthy person, having ankylostomes, begin to suffer from ankylostomiasis? In the first place, it is natural to suppose that the worm, fixing itself as it does on to the intestinal wall, causes the anæmia (to some extent at least), by extracting the blood from the vessels. A healthy adult, weighing 10 stones, possesses nearly eleven pounds of blood. The amount of blood which one ankylostome would remove is therefore negligible. In point of fact, in countries where ankylostomes are indigenous, it is a common experience to find many healthy inhabitants who have ankylostomes in their intestinal canal, and whose dejecta contain numberless eggs.

It is now fairly generally accepted that an otherwise healthy man will not suffer from the disease, unless and until he has harboured 500 worms for a period of six months. Considering the size of the worm, and the amount of blood in the tissues, this seems a small number, but there are certain facts which serve to explain this. In the first place, the worm is very wasteful with the blood. The red discs pass through the body of the worm almost unaltered; the worms appear only to use the plasma, or fluid part. Secondly, the irritation which the worms produce prevents the proper secretion of the intestinal juices, and, as the worms are found aggregated in the first portion and upper part of the second portion of the intestine, this has a great influence upon the digestive process; and, in consequence, the sufferer does not get the proper amount of nourishment from his food, and he will be (from this fact alone) inclined to anæmia.

The history of the parasite having now been traced, it is easier to see how the symptoms are produced. As has been said, the marked symptom of the disease is a profound anæmia, and is caused by the extraction of the blood from the system by the worms. There are several kinds of anæmia, in which the blood may show either qualitative or quantitative changes or both; but this form is a true simple anæmia, that is, it is a quantitative change, due simply to the deficiency of blood, and neither to a wrong proportion of the normal elements nor to the presence in the blood of constituents not normally present.

It would be needless to enumerate all the various and progressive conditions due to anæmia. It is only necessary to say that the whole body suffers in every part; directly, because there is not sufficient blood to enable the patient to do his ordinary work, and remotely, because, owing to lack of proper repair of the organs, they undergo degeneration, and cease to perform their function properly. Owing to the anæmia, the intestinal juices deteriorate in quality or in quantity or in both particulars. When to this is added the fact above mentioned, that the presence of the worms in the intestinal canal causes irritation and secretion of mucus instead of the proper juices, it is easy to understand the very common phenomena observed, namely, the presence of undigested food and mucus in the dejecta, wind, and ravenous, and often perverted, appetite. The whole danger of the disease arises from the anæmia, and the symptoms are nearly all the results of this anæmia.

One prominent symptom not due to this has been found in many cases, particularly in those working with or in damp soil; this is a peculiar itching of various parts of the skin, often accompanied by a rash like a nettle-rash, which, through the irritation of scratching, may become pustular. Since Looss showed that the rhabdite could gain entry into the skin, it has been shown that the irritation is due to their presence in the hair-follicles. In the Dolcoath epidemic this symptom was very prominent. An interesting fact in connection with this symptom has been brought to light by Bentley. In Assam, where ankylostomiasis is endemic, there is a skin-affection among the agriculturists, coincident with the onset of the rainy season. This is known by the natives as "panni-ghao" or "ground-itch." Bentley has shown that this is produced entirely by the rhabdite, and that it occurs in both those actually suffering from ankylostomiasis and in those who are apparently healthy; many of the latter, however, are found to harbour ankylostomes in their intestines.

Another symptom was first noticed by Delamere; he describes it as a peculiar marking of the tongue "exactly as if the patient had just wiped a penful of Stephens' blue-black ink on his tongue." This was noticed in British Guiana, and it was objected by Duprey that this marking was due to the natives chewing a certain root. As Delamere was treating all kinds of natives, all supposed to be chewing the root, it is strange that the black marking should be confined to those patients in whose dejecta he found ankylostomes. Still more curious is it that Dr. Robert Howard, of Lake Nyasa, British Central Africa, should state that he sometimes saw the black marking, and in every native so affected whose dejecta he had examined he had found ankylostomes. Daniells has found a pigmentary degeneration of the organs in non-malarial patients dying of ankylostomiasis. This points to something more than can be accounted for by mere anæmia. Daniells explains it by the supposition that the worms excrete a poisonous substance, which is absorbed from the intestines, and has a deleterious influence upon the tissues.

The disease is dangerous only when it is not diagnosed, and therefore not treated. A few ankylostomes will probably do little harm, except perhaps through the æsthetic objection that one has to harbouring parasites. But when numerous ankylostomes are tapping the blood for long periods, the changes produced may be so profound that recovery becomes impossible; many cases are on record where the patient has succumbed to ankylostomiasis, even though at the time of his death all the ankylostomes have been expelled. In a healthy man a few ankylostomes might hardly be worth removing, if

it were not that he is a source of infection, and that for a long time; the parasites may live for 4, 5, or even 8 years in the intestinal canal. As the appearance of the disease in an individual depends upon the dosage, and as no idea of the number present can be obtained until they are expelled from the body, it is surely better to err on the safe side and get rid of them.

In miners, who are more anæmic on account of their work than those working aboveground, it would be very unwise to neglect the disease, for both reasons. Firstly, because a smaller number of ankylostomes would probably cause the disease in their case, and secondly, because they would be a source of infection not only to themselves but also to their fellow-miners.

The diagnosis of the disease is simple, as is also that of the infection. The ova are very numerous in the dejecta, and under the microscope are easy to see. The prognosis is good if the disease is diagnosed early, but bad if not diagnosed. The treatment consists in expelling the worms, and reducing the anæmia by appropriate medicines.

That "prevention is better than cure" is as old a maxim as it is true. The recent epidemics at Dolcoath, at Liége, and in Westphalia, need only be mentioned to prove that it would be undesirable to have an epidemic on these fields, where labour already is somewhat scarce. The methods of prevention are probably much easier to indicate than to carry out.

Firstly, the worms should be eliminated from all those harbouring them. This seems to be quite impossible, since many on the mines may be harbouring them, and yet be in perfect health. At any rate, no person found to be suffering from ankylostomiasis should be allowed down the mine until all the ankylostomes have been expelled. This is done by giving male fern, thymol, or santonin, calomel, and quinine, keeping the patient under observation and examining the dejecta until no ova are found in them. It is here to be remarked that it frequently happens that ova disappear and reappear even though re-infection has been impossible, and this is due to the fact that the young forms are much less affected by the anthelmintic than the adult worms, and they become mature and reproduce after the exhibition of the medicine.

Secondly, the dejecta should be treated in such a manner that the ova are killed and prevented from hatching. The ordinary methods of sewage-disposal are not applicable in this disease, since the ova are neither killed nor prevented from hatching. The method which has been adopted, both in Cornwall and Westphalia, is to place all the dejecta in carbolic-acid solution, as this kills the ova easily and quickly. Whether it is possible on the Rand to do this, the writer, unfortunately, is unable to say. It seems to him, from his slight knowledge of the native, that it will be difficult to prevent the latter from voiding his dejecta wherever he happens to be at the psychological moment. Aboveground, it may be a comparatively simple matter to adjust; but the most dangerous place to get infected is, undoubtedly, the mine itself, and this will be the most difficult place to keep sterile.

Fortunately, no epidemic of this disease has appeared nearer to the Rand than Kimberley, and it may be remarked that it is time enough to think about the risk of infection when the disease has made its first appearance.

M. W. B.

THE COONEY GOLD- AND SILVER-REGION, NEW MEXICO.

The Mogollon Range. *By* W. J. WEATHERBY. *Mines and Minerals*, 1901, *vol. xxii., pages* 97-101, *with* 5 *illustrations in the text.*

The Cooney mining district is in that portion of the Mogollon Mountain range which lies in Socorro county, New Mexico. The formations are essentially volcanic, and the predominating rocks are andesites. The two largest veins are the King and the Queen, each over 10 miles in length and from 10 to 40 feet wide, and both have the same general north-and-south trend as the range. Both carry gold and silver, with little or no copper. The Queen is a true fissure, but the King is better described as a fissured faulted zone. Other valuable veins, a mile or more in length, lie between the King and Queen, and in some cases cut through them.

There are about 200 locations, each 1,500 by 600 feet, in the Cooney district, and nearly one-third of these have produced ore running from £12 to £30 (60 to 150 dollars) per ton. But the future great wealth of the district lies in the large bodies of £2 to £4 (10 to 20 dollars) ore.

Until recently, the milling has been exclusively performed by the pan-amalgamation or Washoe process. The best saving ever attained by this process was a short run at the Maud S. mill which produced bullion for 83 per cent. of the battery-assays. But the average saving in all the mills has been less than 60 per cent. and in some instances, for many weeks at a stretch, has been less than 50 per cent. of battery samples.

The Helen Mining Company have added Dimmick sizers and concentrators to their stamp-mill at Graham, and by the combined process of amalgamation and concentration, there is a saving of from 93 to 97 per cent. The Dimmick machines are unique, in that neither classifiers nor concentrators require any motive power, and can be made complete on the spot. The sizing and classifying is accomplished in a specially-arranged and partitioned V tank, 15 feet long and 10 feet high, with sloping sides and perpendicular ends. The sands are first separated from the slimes, and the latter gathered into a closer consistency of pulp and water by submersion and suction, without the least loss of values, the excess water removed being quite clear and classification being made up to 120 meshes or finer. Each size falls into a separate apartment, passes to its own launder and thence to its proper concentrating-table. By ordinary methods of hydraulic sizing, water is continually added, so that, owing to excess of water, satisfactory concentration can seldom be attained. The Dimmick table is without motion, and consists of an even surface covered with canvas and thickly studded with nails. The table is given a pitch depending on the coarseness of the pulp, the nails act as riffles, and when the table becomes loaded with concentrates, the valuable product is removed in a minute by means of a hose carrying water under pressure. The same company have installed a pipe-line over 6,000 feet long, up Whitewater Creek, at a cost of about £20,000 (nearly 100,000 dollars). The mill is thus run a large portion of the year by water-power and electricity conveyed to the mines for the operation of an air-compressor plant and electric hoist.

At the Last Chance mines, three standard concentrators have been erected. The table is of the bump type, freely suspended from three points, little power is required to drive it, whilst the force of the bump and also the degree of inclination can be regulated with the utmost precision. The surface is covered with linoleum, the table weighs about 1 ton, occupies a floor-space of 11 feet by 15 feet, handles 15 to 20 tons of ore per day,

and uses only 3¼ gallons of water per minute. The top, or feed, end of the table is much narrower than the discharge end. Standing at the lower end, one sees a series of small wooden riffles, parallel to the base, extending the whole length of the table, but only covering two-thirds of it from right to left, the remaining one-third on the left being smooth linoleum. The riffles vary in height from about ¼ inch on the right to about ⅛ inch on the left, where they give way to the clear unriffled or final cleaning space. The bump tends to throw the metallics completely to the left wall of the table but as they pass from the riffled portion to the unriffled space, they meet the opposing force of the wash-water—the resultant of the two forces causes them to travel down the smooth surface, continually subjected to the cleaning action of the water until they reach the receptacles at the discharge end. The heavier the mineral, the farther to the left on the clear space is it thrown. At the Last Chance mill, towards the left wall of the table, can be seen a downward moving yellow line of gold; then to the right after a blank space, the parallel line of bluish-black silver sulphides, whose specific gravity is about 7; then a line of yellow gold-bearing pyrites whose specific gravity is 5·2; and finally the whitish wild iron-pyrites, or marcasite, having a specific gravity of 4·7.* Concentrates and tailings alike are thus discharged over the base end of the table, the former on the smooth and the latter on the riffled side. It is proposed to treat middlings of any appreciable value by the cyanide process. X. Y. Z.

THE SILVER-MINE OF TEXAS.

The Silver-mine of Texas. *By* HENRY M. ADKINSON. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiv., pages* 150-151, *with* 2 *illustrations in the text.*

The silver-production of Texas is entirely the output of the Presidio mine, near Shafter, Presidio county.

The Presidio mine was opened up about eighteen years ago, and has been a constant and notable producer ever since. A bulletin issued in January, 1902, by the Texas Geological Survey stated that during the past fourteen years the mine has produced £1,200,000 (6,000,000 dollars) worth of silver, whilst the *Mineral Industry*, from 1893 to 1900, gives £60,000 (300,000 dollars) as the average annual production for those eight years.

The region, around Shafter, is composed of a dolomitic limestone, which has been tilted from its original position by the intrusion of the igneous mass forming the Chinatti mountains. In the vicinity of Shafter, these mountains lie generally east and west, and the mine lies on the southern side of the range. The southerly dip of the limestone-strata varies from 20 to 45 degrees. Accompanying the Chinatti uplift, dykes of a porphyritic-felspar character were intruded into the limestone without penetrating to the surface. The dykes seem to influence the location of the ore-bodies, in that the greater portion of the ore has been found in their vicinity, though not always in contact. In general, the ore of the Shafter district is an argentiferous galena, with surface-indications of copper, although none of the latter is mined. In the Presidio mine, however, the ore is a free-milling silver chloride, carrying traces of gold, with only occasional pockets

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 179.

of high-grade lead-ore. The line of demarcation between the silver-chloride and the argentiferous galena ores seems to lie about ½ mile west of the Presidio mine.

The ore in the Presidio mine occurs in pockets and also as impregnations of certain limestone-strata. Some of the pockets, stoped out, are 50 to 60 feet high and hundreds of feet square. The impregnated strata are being extensively worked at present, and these follow the dip of the country.

X. Y. Z.

COAL-MINING IN NEW ZEALAND.

Report of the Royal Commission appointed to inquire and report on the Working of the Coal-mines of New Zealand, 1901, 33 *pages*, *Wellington, New Zealand.*

The Commission was appointed on November 22nd, 1900, and its powers were extended on April 3rd, 1901.

The Commission recommend the appointment of a chief inspector of coal-mines, and that each district-inspector shall report monthly to the chief inspector. In case of difficulty between the inspectors and the mine-owners, it is suggested that the chief inspector shall be furnished with special powers to act promptly and effectively, in order to remedy what may be amiss. Under the present system, the inspectors report annually to the minister of mines, and this has led to matters being allowed to stand over which ought to have been dealt with at once. The inspection-districts also, in the Commissioners' opinion, are too large; additional inspectors should be appointed, the mines should be inspected more frequently, and the forfeiture-clauses enforced where mines are left unworked or neglected for considerable periods.

The Commission further urge that surveys of coal-bearing lands, and of lands suspected to be coal-bearing, should be thoroughly taken in hand, and a determined effort made to ascertain how far the colony can rely upon a coal-supply for the next generation. Immediate efforts should be made to ascertain where coal-bearing areas are situated on crown lands, and they recommend that such lands should not be sold. It is pointed out that, whilst under certain conditions, freehold lands may be resumed for coal-mining purposes, yet the compensation to be paid to the owner generally prevents such resumption. The Commission strongly urge that all coal-areas not now worked should be reserved to the state. The establishment of coal-mines owned and actually worked by the state was much pressed upon the Commission, but the question involves so many political considerations that it can only be dealt with by legislation. But in the meantime, the acquisition by individuals of areas which may be required by the people generally should be prevented.

The Commissioners were much pressed to recommend a differential haulage-rate on the various classes of coal carried by rail. The question is, however, one for railway-administrators, and the Commission commend the subject to the serious consideration of those authorities.

Much evidence was also taken on the subject of the cost of coal to the consumer, as compared with the cost of production. The difference consists of the cost of distribution. A striking example of this latter cost is quoted. The Westport Company's coal, which is produced at 7s. 10d. per ton in the railway-trucks at Waimangaroa is retailed in Wellington at 35s. per ton nett. Also Mokau coal, produced at the mine at 8s. 6d., is sold retail in

New Plymouth at 34s. per ton. The same proportion practically exists throughout the colony. The Commissioners believe that if the State, which now buys a large quantity of coal at a moderate price, would sell such coal at a fair price to consumers, the grievance now complained of would vanish, and the result would be that, while the state would fix the fair retail-price of coal, the present dealers would sell at the same price and would not be injured.

Nearly all the coal worked is brown, lignitic or pitch. The method of working in New Zealand is usually bord-and-pillar; very little longwall is seen, and several of the mines are open working. A few mines are ventilated by fan, one or two by furnace, and several by the exhaust-steam from pumps, but the majority of the mines are ventilated by natural means alone. In 1900, the men ordinarily employed above-ground numbered 617, and below-ground 1,843, the total number being 2,460. The output for the year was 1,093,990 tons, of which 898,286 tons were coal, and 195,704 tons were slack.

The detailed accounts, given in the body of the Report, of the Commissioners' visits to various centres are extremely interesting, and in some few instances, distinctly amusing. X. Y. Z.

THAWING AURIFEROUS GRAVELS BY STEAM.

Mining on the Klondike. *By* A. J. Bowie. *Mines and Minerals*, 1901, *vol. xxi. pages* 529-534, *with* 5 *illustrations in the text.*

The writer describes the "firing" methods of sinking and drifting in the frozen gravels of the Klondike region. In 1898, however, it is stated that experiments began to be made of thawing by steam, and though the apparatus first used was very crude, the experiments gave very encouraging results. During the winter of 1899-1900, as the plants were improved, it was demonstrated that the method of thawing by steam possessed very great advantages over the method of firing previously employed.*

A thawing plant should consist of a boiler, pipes, set of points, and a hoisting-engine with drums complete. Each point requires at least 2 horsepower, and a plant with 10 points should have a 30 horsepower boiler. The boiler should supply dry steam. Locomotive-boilers have given the best results, but any good boiler will do the work. In view of the rigorous climate, special protection should be given to the main steam-pipe. The size of the main feed-pipe is regulated by the number of points; 10 points demand a pipe 1 inch in diameter. In the drifts, the steam-pipe is fitted with unions at convenient distances for disconnecting and drainage-purposes. The feed-pipe is carried down the shaft, and along the drift to the breast where a T is placed, and a cross-head run the full length of the face to be thawed. The cross-head is fitted with valves, 3 feet apart, each point having its own valve. A length, 6 feet, of ½ inch steam-hose connects the point with the valve.

The point consists of an iron pipe, ¾ inch in diameter, 3½ feet long, drawn to a point at one end with a discharge ⅛ inch in diameter; having on the other end a heavy steel head, 1½ inches in diameter, 4 inches long, welded or screwed on; and in its side is placed a ⅜ inch nipple connecting with the hose. For draining the point each morning, a radiator-valve with a

* *Trans. Inst. M. E.*, 1900, vol. xix., page 564.

union attached is used. The hose is fastened to the nipple with baling wire, the nipple being first heated and inserted hot into the hose. When all the pipes have been connected, steam is turned on.

In starting the points, they are held against the face one by one and worked into it as the ground thaws, for about 1½ feet, being driven with a wooden mall for the remainder of their lengths. The entering of the point sufficiently far to enable it to hold its own weight requires about 5 minutes, but it takes quite 3 hours to work 10 points in for their full lengths. The points being in, a full head of steam is turned on, and they are allowed to remain in the breast till 5.30 a.m. on the following day, supposing the pointman to have begun his shift at 6 p.m. on the previous day. When the points are withdrawn, the pipes are disconnected, and the water pumped from the sump. An examination of the ground will show that the breast has been thoroughly thawed, 6 feet high and 8 feet deep. In contradistinction to the firing system, the thawed mass does not (in order to avoid its rapid re-freezing) require to be removed at once; the cobbles and stones in the gravel retain the heat, and do efficient thawing even 24 hours later.

The great advantages of thawing the gravel by steam, as compared with the system of firing, are:—(1) It can be used at all seasons; (2) there is greater security to life; (3) there is no loss of time; (4) dead-work is reduced to a minimum; (5) waste is more economically handled; (6) the control over the heat is absolute; (7) fuel is economized; (8) the gravel is better thawed, its removal is more economical and expeditious, and with the use of a small hoist, there is additional economy of labour with an increased output. As rough examples of comparative costs of firing and steaming, the writer states that in 1899, under the ordinary firing system, the cost per cubic yard of gravel extracted from a mine on Dominion Creek was from 17s 6d. to £1 4s. 6d. (4·2 to 5·91 dollars); and in 1900, at a mine on Sulphur Creek, where the newer method of thawing by steam was employed, the cost was 7s. (1·69 dollars) per cubic yard. X. Y. Z.

WORKING DEEP COAL-SEAMS.

A New Method for Working Deep Coal-beds. *By* H. M. CHANCE. *Transactions of the American Institute of Mining Engineers*, 1900, *vol. xxx.*, *pages* 285-290, *and* 1112-1115, *with* 1 *illustration in the text, and* 1 *plate.*

The writer emphasizes the difficulties of ventilating the ever-extending workings of deep mines so as to carry off the explosive gas, which is generally found to increase in quantity with the depth. He points out that what is considered an excellent roof, in a seam of moderate depth, becomes a bad one, unable to stand the pressure of a great thickness of overlying strata. He considers the greater danger of "squeeze," the general crushing-down of the pillars of coal left to support the roof in deep seams. After enumerating the many sources of increased difficulties and the consequent advance in the cost of working by the ordinary methods, he describes a new system of driving out and working deep coal-seams, showing various adaptations to meet the conditions of gradient, soft coal, water, etc., and he claims that it possesses many advantages, without increasing the cost of production. The paper is illustrated by a plan, without the aid of which a detailed description of the methods suggested would become very involved. A. W. G.

GOLD-DREDGING IN THE UNITED STATES.

(1) *Gold-dredging in North Georgia.* *By* HENRY V. MAXWELL. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., page 564, with 2 illustrations in the text.*

Recent experience, on the Chestatee and Yahoola rivers, demonstrates that owing to the existence of submerged timber in the placers along the banks and the jagged outcrops of country-rock in the present river-beds, chain-dredges cannot be successfully operated and dipper-dredges only are employed. Two styles of these are employed, and they differ materially only in displacement and capacity. The dippers are of ¾ yard and 1 yard capacity, and the speed is about one dipperful per minute. In the one, an auxiliary sluice-boat is constructed, whilst in the other, two sluices (one on each side of the main boat) are built. In the first, all material is dumped into an iron-bottomed box, 10 feet square, into which 2,000 gallons of water are forced by a centrifugal pump placed under the deck, and operated by steam conveyed through indiarubber-hose from boilers on the main boat. The stream carries the sand and gravel into two sluices, 60 by 3 feet, leading from the box. These have a grade of ¼ inch per foot, whilst racks are placed in the bottom to catch the gold. The heavy rock not moved by the water is dumped by hand over the side of the sluice-boat. Thus the refuse is piled directly behind the sluices, and upon the side farthest from the main boat, so that the boats can be dropped down stream to another trough without re-handling the material.

In the case of the second style of boat, similar methods obtain, except that by dumping into sluices at both sides, the refuse often has to be moved a second time. Conditions vary, however, and both methods are successfully employed. An experiment with a suction-pump is soon to be made, as well as an effort to save the black sand, which is abundant and runs from £4 to £21 (20 to 100 dollars) per ton. Recently one boat, finding it impossible to operate, owing to the excessive quantity of submerged timber, suspended dredging, and employed a lift operated with water from the boat. By this method some high values were obtained.

(2) *Dredging for Fine Gold in Idaho.* *By* ROBERT BELL. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 241-242, *with* 2 *illustrations in the text.*

In spite of a general impression to the contrary, the successful recovery of fine gold from the Snake-river placer-beds has been an accomplished fact for many years. The adaptation of the floating dredge to the conditions here encountered seems to have opened up an extensive field for profitable gold-mining.

The Sweetser-Burroughs dredge-boat was built in 1894 at a point 30 miles south-west of Minidoka. This suction-dredge, started with a 6 inches nozzle, which was changed in 1895 to one of 10 inches, has been in constant and successful operation during the open season ever since. The hull of this boat is 30 by 90 feet, drawing 3 feet of water, and the dredge has an actual daily capacity of 2,500 cubic yards. Motive power is supplied by a 125 horsepower vertical compound-condensing marine engine, receiving steam from two return-tube boilers. The gravel is discharged into a stationary sluice, 12 feet long, set nearly horizontal, in order to check the velocity of the stream of gravel before it passes to the adjoining two lengths of shaking sluice, each 17½ feet long and inclined at 1 in 24. The sluices.

5 feet wide, are arranged to shake endways with a 3 inches stroke. The sluice-bottoms are made of perforated steel-plates, No. 10 gauge, $\frac{1}{8}$ inch holes, spaced $\frac{3}{8}$ inch apart. The coarse material passes to an indiarubber belt-conveyor, which deposits it sufficiently astern to prevent it from interfering with the operation of the boat.

The fine material, including the gold, after passing through the shaking-screens, is discharged into a distributing-box, which feeds it evenly to a set of 16 inclined burlap-tables, with an aggregate surface-area of 1,000 square feet, set at right angles to the sluices. The burlaps are taken up at intervals of 6 or 8 hours, and washed in a wooden tank, from which the accumulated gold and black-sand concentrates are elevated automatically to the amalgamating-room; quicksilver is here added, and the gold readily separates by a simple barrel-process of amalgamation, after which the amalgam is retorted, melted and run into bars, and shipped to Boise, where it realizes £4 (19 dollars 40 cents) per ounce.

The cost of handling gravel at this plant, including all charges, is 2½d. (4½ cents) per cubic yard, and affords a handsome margin of profit. A new dredge-boat, built in 1899, is of the chain elevator-bucket type, the digging buckets are of 5 cubic feet capacity, and the boat has shown an actual working capacity of 2,000 cubic yards per day over a period of 20 consecutive months. The gold-saving arrangement is about the same as on the first boat described. Both plants work continuously throughout the 24 hours, both are lighted by electricity, and both are connected with the railway-station at Minidoka, and with each other, by telephone.

X. Y. Z.

THE GOTHAN STRATAMETER.

(1) *Der "Stratameter" von Hermann Gothan in Gross-Lichterfelde.* *By* H. THUMANN. *Glückauf*, 1902, *vol. xxxviii., pages* 55-57, *with* 1 *illustration in the text.*

(2) *Der Gothan'sche "Stratameter": Apparat zur Ermittelung des Streichens und Einfallens der Gebirgsschichten in Bohrlöchern und der Abweichung der letzteren von der Lothlinie.* *By* H. THUMANN. *Zeitschrift für praktische Geologie*, 1901, *vol. ix., pages* 389-391.

This instrument, for measuring the dip of strata in deep bore-holes, consists of a train of clockwork which at a given moment, arrests a compass mounted on the upper surface, and simultaneously releases a plummet situated below. The whole is mounted on a brass cylinder, 14 inches deep and 2 inches in diameter, so that the clockwork and compass are visible at the top and the plummet and marking disc at the bottom. At the moment of arresting the needle three equidistant teeth on the compass-rim press up into an indiarubber disc and restrain any further movement of the needle. The brass plummet carries a properly centred steel point, which on coming into contact with the recording disc, of tinfoil or paper, makes an indelible mark upon it; and as the plummet point then retreats into the body of the plummet, there is no risk of the mark being obliterated. The brass rim round the disc is inscribed with the four points of the compass.

For use, the stratameter is enclosed in a double case of delta-metal which is attached to the boring rods, and is closed by a conical plug which seals it hermetically. This case is 40 inches long, and to it are attached the

core-barrel and boring crown. Before breaking off the core, work is stopped for 20 minutes, to allow time for the needle and plummet to attain a state of repose (the plummet-barrel is filled with oil to restrain oscillation). On raising the tool, and removing the head-piece of the stratameter, the north-and-south position of the arrested compass-needle is marked or painted on the core itself, by the aid of a zinc cylinder. The core is next taken out and placed on a board, so that the north-and-south marks correspond with a line on the latter; the plummet-barrel is placed on the core, and by means of the freed compass-needle and the plummet—which must coincide with the mark made on the disc while in the bore-hole—the core is adjusted to the position which it occupied in the hole, whereupon the dip of the strata can be measured. By the aid of the plummet-mark any deviation of the bore-hole from the vertical can be ascertained and measured, which is an important feature when a series of parallel holes for shaft-sinking by the congelation-process is in question.

The author dwells on the advantages of this appliance as compared with any other system. He cites a case in the north of France, where a bore-hole had been put down to a depth of 1,245 feet and then abandoned. A German firm undertook to continue the bore-hole, and met with great difficulties on account of serious deviations from the vertical; these had arisen, because the crown of a borer which had stuck in the strata had been passed by. The disputes which ensued thereupon were satisfactorily settled by means of the Gothan stratameter. L. L. B. and C. S.

FLOTTMANN PNEUMATIC ROCK-DRILL.

Die Flottmannsche Gesteinsbohrmaschine. *By* — LIMBERG. *Glückauf*, 1902, *vol. xxxviii., pages* 217-219, *with* 1 *illustration in the text and* 1 *plate.*

The Flottmann drill consists of a cast-iron cylinder enclosing a Siemens-Martin steel piston with a long bearing-surface, and guided by the piston-rod or main spindle moving in a long bearing packed with a broad leather collar in the front cylinder. The auxiliary valve is pivoted, and swings to and fro under the influence of shoulder-pieces on the reciprocating piston, thus automatically setting the piston of the main-valve for the admission of compressed air to each end of the cylinder in turn. This arrangement is designed to reduce the wear caused by the high friction in the ordinary shell-valve.

The twist spindle is rifled, mounted on a ratchet-wheel in the back cylinder-head, and is connected with the hollow main spindle by means of a nut. During the return of the drill-spindle, the rifled spindle is held fast by pawls, and thus imparts the necessary twist to the drill-point, but during the forward stroke the pawls release the rifled spindle, and enable a straight blow to be delivered on the rock. By an arrangement of channels in the rifled spindle, nut and piston, the full working area of the latter is utilized in the forward stroke. A slight cushioning effect is produced at each end of the cylinder by a special disposition of the air-ports, to prevent the injurious impact of the piston on the cylinder-heads. C. S.

DEVELOPMENT OF ELECTRICALLY-DRIVEN ROCK-BORING MACHINES.

Ueber die Entwicklung der Gesteinsdrehbohrmaschinen mit elektrischem Antriebe. *By* C. SCHRAML. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix.*, *pages* 263-266, *and* 1 *plate.*

The Siemens-and-Halske electrically-driven rock-boring machine was introduced into Austrian salt-mines about 1894, and many hauling, boring, and ventilating engines are now worked by the same power. Improvements in boring-machines, on the lines of the best hand-drills, and combining the advantages of both types, are much needed. The first Siemens-and-Halske machine, already described,* had a differential thrust, a motor-box, and a flexible shaft, and this inconvenient three-fold division of the parts was avoided in the next, which was more compact. Experiments have been suggested or made on three types of drills, the Siemens-and-Halske, the Union and the Bornet, to determine which is the best.

The experiments on the Siemens-and-Halske and Union machines were made in 1900, and were comprised in a 6 hours' shift for two men. This shift was too short, 30 per cent. of the time being employed in going to and fro, 32 per cent. in removing the material, and 38 per cent. in the actual work of boring. In four experiments made with the Siemens-and-Halske machine, 17 holes were bored; in three with the Union 19 holes were bored. For every 3½ feet bored in rock of medium thickness, the total average time required to erect the machine was with the Siemens-and-Halske, 18 minutes; with the Union, 11 minutes; and for actual boring 13·7 minutes, and 6·8 minutes respectively. The great speed of the Union machine, due to the absence of a brake, was not an advantage, and the Siemens-and-Halske machine was able to pierce hard anhydrite, which the other drill could not touch. Holes were also drilled in the roof, floor and sides of the mines; the roof-holes took 12 per cent. less time for the same depth, because the bore-dust fell out easily, and did not impede the action. The number of drills used in the same kind of rock was noted for a month, and was 12 per cent. more with the Siemens-and-Halske machine. The wear of the drill depends on the nature of the rock, but neither machine could be worked continuously in hard rock, both becoming overheated in 34 and 37 minutes respectively. E. M. D.

MECHANICAL COAL-CUTTING.

Organisation d'un Service de Havage Mécanique dans une Mine de Houille. *By* A. DE GENNES. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 31-40.

Although many attempts at working coal by mechanical means have been made in France, especially during the past two years, not one has yet entered the stage of application on a large scale to a whole colliery.

The causes of this slight success in France are of two orders, material and moral. With respect to the first, the deposits are less regular, as regards thickness and dip, than those in the United States; and the roofs are generally bad, so as to require much timbering, which interferes with the working of the machine. This accounts for the restricted use of the chain coal-cutter; but it is not sufficient to prevent the use of pick-machines. Wherever coal requires the use of the pick, it can be better worked

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 719.

by a machine than by manual labour; and this truth will in a few years become generally recognized, the miner's two-pointed pick being superseded by the coal-cutter.

The three greatest natural obstacles to the use of the pick-machine are a bad roof (requiring much timber), high dip and slight thickness of seam. The difficulty as to timbering, though great, is not insurmountable, for the pick-machine can work in the midst of timbers only 3¼ feet (1 metre) apart in every direction; and in a Pas-de-Calais colliery, with hard coal and a dip of 20 degrees, a machine has worked at the rate of 13 feet (4 metres) per hour, including the placing and shifting of the platform, while making a cut nearly 5 feet (1·5 metre) deep.

As regards the difficulty of dip, French engineers have done even better than American, for at two collieries in the south of France seams dipping 40 and even 45 degrees have been worked by a machine fastened to a timber by a chain, with or without pulley and counterweight, while in the United States, the limit is 14 or 15 degrees.

The third difficulty is insurmountable because, when the thickness of the seam is less than 3¼ feet (1 metre) the position of the workman is too difficult; and, although an experienced miner can work in a seam of 2 feet 8 inches (80 centimetres) and even less, such seams are certainly not favourable for a new departure.

The conditions depending on the human element are more serious, because every one in the colliery, from the general manager to the working miner, has to be considered. The former is lured on by the prospect of greater output without increase in the number of hands; and then each official has his own opinion on the matter, while the observation of an eminent chief-engineer that "for new tools fresh methods are required" is often ignored. To his great surprise, the author has found that the least resistance is offered by the working miner; but, after all, what the hewer has to say is of no great consequence, because it is not he who will have to work the machine, although his experience in timbering will find him occupation.

As a solution of the problem, the machine should by preference be entrusted to young, active and skilful men, as they are more suitable for this work than those possessing great physical power. The time lost in becoming accustomed to a machine is largely compensated later on; and the fatigue experienced at first is surmounted after a little practice. The man who is to take charge of a machine should begin as second hand.

There are only three valid excuses for slight production—want of picks, want of pressure, and the necessity of waiting for a place to be cleared in which the machine can work; and these three requirements should be looked after by the overman.

Any large plant of mechanical coal-cutters, should be placed under the charge of a skilled miner, or better still a mechanic accustomed to underground work, taking his orders directly from the underground manager, and pecuniarily interested in his work. He should also have been accustomed to the actual working of the machine; and, if the mine be not very large, he might too have charge of the compressed-air pipes.

Independently of the supervision exercised by the under-manager, it is advisable, in a large colliery, to train a young mining and mechanical engineer in the use of coal-cutting machinery, especially at the commencement of its use; and, while it is important to unify methods, he will with advantage keep the manager or general manager informed as to the progress of the work. J. W. P.

EXPERIMENTS WITH PICK COAL-CUTTING MACHINES.

Versuche mit stossenden Schrämmaschinen. By — Brandi. *Glückauf*, 1903, *vol. xxxix., pages* 628-631.

The writer describes experiments made:— (1) To ascertain the amount of air and time consumed by the machine under as normal conditions as possible, in the case both of new machines and of those which had already been used and of different makes and sizes; and (2) to test a number of cutters.

The experiments were carried out in four galleries in two coal-seams, varying from 22 inches to 36 inches in thickness, and one contained a slate-band, 2 inches thick. The holing was made with the striking as well as with the swinging movement, in the coal as well as in the slate-band. A skilled workman managed the machine, with an assistant. The necessary volume of compressed air was stored in a cast-iron boiler (with a capacity of 300 cubic feet), it was connected with the principal supply of compressed air, and fitted with a spring pressure-gauge. The machine was worked with the air contained in the boiler, till its pressure had fallen from 4 to 4½ atmospheres to 2·8 to 3 atmospheres. If the air in the boiler at the beginning of an experiment had a pressure, a, it received $(a+1)$ times the boiler-contents of air at no pressure; if the pressure were b atmospheres at the end of the cutting, it received $(b+1)$ times the boiler-contents. It was therefore only necessary to record the difference of pressure in the boiler before and after each period of cutting. The sum of these differences, multiplied by the volume of the boiler, showed the amount of air consumed by the machine during the entire period of cutting.

Seven machines were received from various manufacturers:—Messrs. Frölich and Klöpfel, Unterbarmen; Mr. Korfmann, Witten; Mr. Flottmann, Bochum; and Messrs. Bechem and Keetmann (Eisenbeis), Duisburg.

Only successful experiments have been tabulated, the results according to the different kinds of cutters used, being as follows:—(1) Common swallow-tailed chisels; (2) cross chisels, and (3) those with three radiating cutters. These did not prove unexceptionable. In all three, the length of the stroke varied, in consequence of being moved to a new place. If a long chisel strikes into a short groove the chisel often becomes tightly jammed. This defect shows more or less, accordingly as the coal is tough or brittle. The cutter with five long points (Messrs. Bechem and Keetmann No. 4) and that with five interchangeable blades (Messrs. Frölich and Klöpfel No. 5) avoids this defect. The first-named cutter, in consequence of its smaller diameter, shewed somewhat better results. When both are of the same dimensions, they will be equal in value and are both to be recommended.

The experiments recorded in Table I. show, comparatively speaking, an extraordinarily small consumption of air by all the machines. The experiments are arranged according to the depth of the holing. Even the seemingly greater differences, arising either from varying dimensions, difference of length of time in use, or from the kind of cutter employed, become insignificant when one calculates the cost. Under favourable circumstances 35 cubic feet of compressed air at a pressure of 4 atmospheres costs, on the spot, 0·15d. One square metre was cut, at the normal depth of 5 feet 7 inches with a minimum of 880 cubic feet of air and a maximum of 1,500 cubic feet, or 176 and 300 cubic feet respectively at a pressure of 4 atmospheres. One square metre, accordingly, costs 0·75d. to 1·29d. for air consumed. It is immaterial whether 1 square metre of under-cutting costs 0·75d. or 1·29d. More important is the difference

in the length of time occupied, as the cost of labour per hour for the two necessary workmen at 2s. 7d. per shift is 1s. 7d. (1·60 marks). According to Table I., the quickest working machine under-cut 1 square metre to a depth of 5 feet 7 inches in 21 minutes, the longest in 34 minutes working all the time, which shows a cost of 6·5d. or 10·2d., a difference of 3·7d., or six times as much as the difference in expenditure on the air consumed for holing 1 square metre. The amount of air consumed need not be taken into consideration; but on the other hand we must attach importance to the speed with which the under-cutting is made.

TABLE I.—RESULTS OF EXPERIMENTS FOR UNDER-CUTTING 1 SQUARE METRE, ARRANGED ACCORDING TO THE AMOUNT OF TIME OCCUPIED.

Series.	Machine.	Machine. New or already Used.	Machine. Diameter of Piston.	Machine. Stroke.	No. of Cutter.	Cut.	1 Square Metre Undercut in Minutes.	1 Square Metre Undercut with Air.
	Depth of cut, 1 foot 8 inches (0·5 metre).		Inches.	Inches.				Cubic feet.
A	Flottmann	New	2·76	7·28	5	Swinging outward	18·0	650
	Eisenbeis	Used	2·76	8·07	4	Swinging outward	19·6	950
	.. ..	Used	2·76	8·07	4	Swinging inward	24·0	1,380
	Frölich and Klöpfel	New	2·95	7·87	5	Striking	26·4	980
	Depth of cut, 3 feet 3 inches (1 metre).							
B	Frölich and Klöpfel	New	2·95	7·87	5	Striking	18·0	780
	Flottmann	New	2·76	7·28	4	Striking	20·9	810
	Korfmann	Used	2·76	7·87	4	Striking in slate-band	21·0	880
	Eisenbeis	Used	2·76	8·07	4	Striking	21·0	1,100
	.. ..	Used	2·76	8·07	4	Swinging outward	21·0	1,340
	Flottmann	New	2·76	7·28	5	Swinging outward	22·7	800
	Korfmann	Used	2·76	7·87	4	Striking in slate-band	25·0	990
	Eisenbeis	Used	2·76	8·07	4	Striking	25·0	1,410
	.. ..	Used	2·76	8·07	4	Striking	26·5	1,590
	.. ..	Used	2·76	8·07	4	Striking in slate-band	28·6	1,150
	Frölich and Klöpfel	New	2·95	7·87	5	Striking	32·0	1,270
	Depth of cut, 4 feet 11 inches (1·5 metres).							
C	Korfmann	Used	2·76	7·87	4	Swinging outward	19·0	850
	Frölich and Klöpfel	New	2·95	7·87	5	Striking	18·4	810
	Korfmann	Used	2·76	7·87	4	Striking	22·0	930
	Flottmann	New	2·76	7·28	4	Striking	22·2	900
	.. ..	New	2·76	7·28	5	Swinging outward	23·0	880
	Frölich and Klöpfel	New	2·95	7·87	5	Striking	27·0	1,200
	Eisenbeis	Used	2·76	8·07	4	Striking in shale-band	32·0	1,340
	.. ..	New	2·76	8·07	4	Swinging inward	34·0	1,980
	Depth of cut, 5 feet 7 inches (1·7 metres).							
D	Eisenbeis	Used	2·76	8·07	4	Striking	21·0	1,100
	Frölich and Klöpfel ..	New	2·95	7·87	5	Striking	21·2	890
	Flottmann	New	2·76	7·28	4	Striking	23·5	940
	Eisenbeis	Used	2·76	8·07	4	Striking	26·0	1,480
	Frölich and Klöpfel	New	2·95	7·87	5	Striking	29·0	1,290
	Eisenbeis	Used	2·76	8·07	4	Striking in shale-band	34·3	1,530
	Depth of cut, 6 feet 7 inches (2·0 meters).							
E	Frölich and Klöpfel	New	2·95	7·87	5	Striking	24·0	740
	Eisenbeis ..	Used	2·76	8·07	4	Striking	31·0	1,240
	Frölich and Klöpfel	New	2·95	7·87	5	Striking	34·0	1,020

One should therefore choose the largest and quickest-cutting machines possible, and they should be so well built that one need reckon on no loss of time through breakdowns. These conclusions have been confirmed by many experiments, which, in consequence of the imperfect working of the machine or other hindrances, were only carried out at considerable expenditure both of time and money, and were therefore not included in the table.

It cannot be ignored that small and light machines have the advantage that they can be worked by only one man, but this only refers to the time of setting up and taking down of the machine; in places where there are more workmen it is insignificant. A light weight is not unimportant in the case of rising seams.

From Table I., the average time occupied in cutting 1 square metre in all experiments is shown to be as follows:—19·7 minutes, for a depth of under-cutting of 1 foot 8 inches (0·5 metre); 22·2 minutes, 3 feet 3 inches (1·0 metre); 25 minutes, 4 feet 11 inches (1·5 metres); 27 minutes, 5 feet 7 inches (1·7 metres); and 30 minutes, 6 feet 7 inches (2·0 metres).

These figures show the increase of time required for the same area of under-cutting at an increased depth of cutting, and establish the principle that the cutters should be made as broad as possible, in shape like the segment of a circle. A. W.

THE USE OF EXPLOSIVES.

Recherches sur l'Emploi des Explosifs dans les Mines. By H. SCHMERBER. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 26-28.

The influence of an explosive's sluggishness on its economical effect has formed the subject of long investigations, which have established almost conclusively that, the more sluggish an explosive, the greater will be the difficulty attending its detonation, especially when freely exposed to the air, and also that the more restricted the space in which the charge is fired, the greater will be the chance of detonation of a sluggish explosive. Deficient tamping and too large charges must be avoided; and the best guide to the rational use of an explosive is thorough knowledge of its properties, added to practical experience.

The more sluggish an explosive, the greater difficulty will there be in transmitting the detonation, and also the greater necessity for a good detonator, in order to avoid miss-fires and incomplete detonations. There is now too great a tendency to employ fulminating mixtures, instead of pure fulminate; but this is false economy, because such mixtures deteriorate rapidly, and detonators made with them give many miss-fires, so that the quality of the detonators should be ascertained by frequent tests. The best method is simply to fire the detonator on a sheet of lead in the open air, the quality of the detonator being revealed by examination of this sheet far more correctly than by the Trauzl lead-block.*

In rocks of medium hardness and hard or semi-hard coals it has been the practice to use drill-bits of ample diameter, so as to permit explosives of even slight density to exert their power under good conditions. In hard rocks, however, where very strong gelatine-dynamite is used, there has been a tendency to reduce the diameter of the shot-holes, on economical grounds; but such a practice must be avoided in the case of safety-explosives, as numerous experiments have proved that, if drilling the hole costs a little more, the economical effect of the explosive is practically the same.

J. W. P.

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* *Trans. Inst. M.E.*, 1901, vol. xxi., page 442.

COUPLING OF BLASTING-CHARGES IN ELECTRICAL SHOT-FIRING.

Die Schaltung der Sprengschüsse bei elektrischer Zündung. *By* — HEISE. *Glückauf*, 1902, *vol. xxxviii., pages* 325-329, *with* 4 *illustrations in the text.*

When several shots are to be fired simultaneously, the coupling can be effected in three different ways, namely:—In series, parallel or by groups. Primarily, the choice between these systems is determined by the relative resistances in the electric machine or battery and the igniters. The general rule is that, when the internal resistance in the generator is very high in relation to that of the igniters, coupling in series is preferable; in the converse eventuality, parallel coupling; whilst, where the conditions are intermediate between these two extremes, grouping may be selected. Other considerations, however, intervene, inasmuch as the current in the generators usually employed for shot-firing does not attain its full intensity at once; and, furthermore, there is always some inequality in the resistance of the individual spark- and glow-igniters. The generating machine furnishes a current of very high tension, combined with a great internal resistance, so that when spark-igniters are used, the differences in their internal resistance are relatively insignificant when coupled in series, the spark being sufficiently powerful to fire the whole at once; whereas, in the case of coupling in parallel, the divided current is weakened, and the danger arises of nearly all the sparks passing through the igniter exhibiting the lowest resistance.

With glow-igniters, the conditions are different, because these can be sorted so as to obtain an approximately uniform resistance in a set, but there is always the risk of those with the highest resistance coming first into action and interrupting the circuit. Hence, in this case, parallel coupling is nearly always advisable; series coupling being reserved for occasions where the generator is capable of instantaneously furnishing a specially powerful current, or of being automatically connected when the full strength is attained. With parallel coupling, the irregularities of internal resistance are compensated to a large extent by the subdivision of the current; and, though the shots may not all be fired with absolute unanimity, the intervals are so small as to be negligible, provided, of course, that the resistances are approximately uniform. When series coupling is employed with glow-igniters it is advisable to employ a somewhat stronger current than is theoretically requisite. For example, with igniters of 0·45 ampère, the current used for 3 shots should be 0·6 ampère; for 6 shots, 0·8; for 12 to 15 shots, 1 ampère; and for any larger number, 1·2 to 1·5 ampères.

C. S.

DELAYED IGNITIONS OF EXPLOSIVES.

Neue dynamoelektrische Minen-Zündmaschine, Patent Hans Tirmann, und die verspäteten Sprengschüsse. *By* L. VOLF. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 221-226, *and* 1 *plate.*

A Tirmann shot-firer has been in use since 1900 at a mine in Karwin, and retarded ignitions of the blasting-charge have been observed with it. After the introduction into France of safety-explosives (grisoutine-dynamite, grisounite Favier, etc.), several accidents happened at the St. Etienne collieries, and these were attributed to the phenomenon of double detonation. It was assumed that in a bore-hole charged with cartridges, only the first was exploded by the detonator, and that the others became ignited after

an interval of a few seconds or minutes. The following accident proved this:—Three holes, each filled with 3½ ounces (100 grammes) of *grisounite-couche*, were bored in the coal, and ignited by 0·052 ounce (1½ grammes) detonators and three fuses. Three distinct reports were heard, and, as the workmen were going away, a shot which was still smoking exploded and injured one of them; it appeared to have exploded twice. The theory deduced was that the decomposition of a blasting-charge is not the result of a single chemical reaction, but depends on the pressure to which the products are exposed during such reaction. Dynamite, gun-cotton, nitrate of ammonia, and other blasting materials containing nitrates, decompose gradually in the air, and give out nitric oxide, but if they are ignited in a closed space they instantly decompose, without forming a trace of nitric oxide. The first slow process changes immediately into the second, if the free evolution of gas be hindered, and the pressure raised. The reaction produced by a detonator is the same as that by ignition in a closed space at high pressure. Both are so rapid that the whole of the charge is at once converted into gas. But if the ignition be defective the charge may ignite and burn, instead of exploding; it is then said to "cook," and gives off nitric oxide. The explosive power of a charge also varies with its composition, and depends, in grisounite, upon the small quantity of nitro-naphthalin that it contains. If the charge begins to burn, the increasing pressure caused by the gases given off may produce an explosion, and ignite the cartridges one after the other.

Many experiments were made with grisounite-Favier to obtain retarded ignitions, and these, apparently due to the fuze, have also occurred with the Tirmann incandescent igniter. This apparatus consists of a dynamo, between the poles of which a T-magnet rotates, and contact is made with a nut moving along a spindle. The dynamo is made in three sizes:—The smallest weighs 6·6 pounds and at a distance of 328 feet will fire six fuzes simultaneously; the next size fires twelve fuzes at the same distance; and the largest (weighing 26½ pounds) will fire sixty fuzes simultaneously. The current passes through two insulated copper-wires, $\frac{1}{16}$ inch in diameter. The fuzes being attached to the apparatus the current is turned on, the wire of the fuze begins to glow, and an explosion follows. Thus, there are no dangerous sparks between the electrodes. The fuze has an outer casing of metal-alloy containing the conducting wires, the detonating material, a hollow to receive the detonator and the incandescent wire, made of an alloy of platinum and iridium.

At the Karwin mine, twenty holes were bored and fired in three series. The first and second series having been fired from a distance of 260 feet, a loud report was heard, and the workman was proceeding to fire the remaining holes, when a second report ensued, about 15 seconds after the first. It was impossible to tell which of the shots had produced the first, and which the second report, but all had gone off. The bore-holes were about 4 feet deep, and each contained, besides the firing cartridge, five or six others. On another occasion, six shots were fired at a distance of about 130 feet, and there was an interval of a minute or more between the two explosions. Twenty-five experiments were then made to discover the reason for these retarded ignitions. In two, the dynamite did not explode at all, and in several it was only partly burnt, while three miss-fires were caused by the machine.

The writer attributes these retarded ignitions to the use of an instantaneous induction-current which melted the platinum-wire, and to other defects. In

one experiment, two bore-holes of the same size were drilled vertically into the sandstone, filled with similar charges, and their fuzes ignited at the same moment: nevertheless there were two consecutive reports. Possibly the powder in the fuzes was kindled simultaneously, but the products of combustion did not attain the pressure necessary to force out the tamping at the same moment in both holes. Experiments were also made with an inverted detonator, but retarded ignitions (and not miss-fires) were the result. Sometimes in blasting, the detonator may become damp, and is ignited not by the flame of the powder, but by the hot gases generated by the combustion of the dynamite. Retarded ignitions and smouldering miss-fires are dangerous, and should be carefully studied, to determine whether they are really caused by safety-explosives or incandescent fuzes. E. M. D.

THE RUSSBACH POT FOR SOFTENING OR THAWING DYNAMITE.

Ueber Versuche mit dem Russbach'schen Dynamit-Aufthaukessel "Thermophor." By LUDWIG WÜRTZ. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 228-229.

The Russbach pot consists of two cylindrical vessels, fitting one into the other, with double walls, lined with non-conducting material, and provided with a double lined cover. To maintain an average temperature in the pots of say 122° Fahr. for 10 hours, the inner vessel is plunged for 15 or 20 minutes into water kept on the boil, dried, placed inside the other vessel, and the cover replaced. A number of experiments were made to measure the temperature of the walls of the empty vessel, and of its interior. After placing it for 15 minutes in boiling water, the temperature of the walls when withdrawn was 107·6° Fahr., and of the interior 105·8° Fahr. At the end of 5 hours, they were respectively 102° Fahr., and 87·8° Fahr.; and at the end of 10 hours, 62·6° and 53·6° Fahr. The temperature of the outer air was very cold. After keeping the vessel in boiling water for 20 minutes, the temperature of the walls was 111° Fahr., and of the interior, 109·4° Fahr.; after 5 hours, 100° and 91·4° Fahr., respectively; after 10 hours, 93° and 82·4° Fahr.; and at the end of 13 hours, the temperature of the walls was still 53·6° Fahr. The vessel tested was of 305 cubic inches capacity, and if previously heated as described, 8 to 9 pounds of dynamite at a time could be softened in 3 or 4 hours, and 5½ pounds during the next 4 hours. The pot, however, was too small, because the outer cartridges expanded, and prevented the heat from penetrating to the inner cartridges, and a larger one has been made, but not yet tested.

In the writer's opinion this apparatus affords a means of thawing nitroglycerine compounds with greater ease and safety than any other.

E. M. D.

THE TAMPING OF SHOTS IN MINES.

Commission des Substances Explosives: Rapport sur l'Étude de la Question du Bourrage des Coups de Mine. [OFFICIAL.] *Annales des Mines*, 1901, *series* 9, *vol. xix., pages* 563-578, *with* 3 *figures in the text.*

This report of the Committee on tamping has been approved and adopted by the French Commission on Explosives. The task entrusted to the Committee was the comparison of various methods of tamping, from the

point of view of the utilization of explosives and the dangers in connexion therewith that might conceivably arise. These dangers are of two kinds:—They may originate from the frictional ignition of remnants of the explosive that have remained clinging to the walls of the shot-hole; or from the ignition (by de-tamping) of gaseous mixtures containing fire-damp.

The experiments undertaken by the Committee may be classified in three categories:—

(1) Comparison of methods of tamping, from the point of view of the utilization of explosives. The materials used for tamping were dry quartzose sand, ground very fine; dry clay; water; ordinary damp sand; and clay kneaded up with water to the consistency of putty. The explosives experimented with were:—Grisounite-dynamite containing 12 per cent. of nitroglycerine; gelatine-dynamite of Cugny, containing 92 per cent. of nitroglycerine; Favier rock-grisounite containing 8½ per cent. of dinitronaphthalene; and Favier coal-grisounite containing 4½ per cent. of trinitronaphthalene.

The tabulated results lead the committee to the conclusion that it is difficult to give the preference (in any marked degree) to one method of tamping as compared with another. In practice, they are inclined to think that sand is preferable to clay.

(2) Comparison of methods of tamping, from the point of view of the risks incurred by de-tamping. The general conclusion is that common sand is the most reliable material.

(3) Comparison of methods of tamping, from the point of view of the dangers arising from frictional ignition. The experiments, on the whole, gave negative results; whence the Committee conclude that, although the risk of frictional ignition cannot be dismissed as illusory, it is extremely remote. In fact, if enclosed in properly-made cartridges, no remnants of the explosive should remain clinging to the walls of the shot-hole unless the circumstances are very exceptional.

Summarizing the foregoing conclusions, the Committee finally express the opinion that sand should be recognized as an admissible tamping-material in the case of safety-explosives. L. L. B.

EXPLOSION OF A DYNAMITE-STORE IN THE FÉNELON SHAFT, NORTHERN FRANCE.

Note sur l'Explosion d'un Dépôt souterrain de Dynamite à la Fosse Fénelon de la Compagnie des Mines d'Aniche (Nord). ANON. *Annales des Mines*, 1901, *series* 9, *vol. xx., pages* 521-547, *and* 1 *plate.*

On November 28th, 1900, at 5·15 a.m., a subterranean store of dynamite exploded in the Fénelon shaft, killing 17 workmen on the spot, and inflicting injuries (mortal in 4 cases) on 22 others. Though so appallingly destructive of life and limb, the disaster caused otherwise comparatively little damage: the chambers in which the dynamite was housed were destroyed, leaving an empty cavity, and there were two falls of rock in the neighbouring heading. This dynamite-store was situated on the 1,640 feet level, about 170 feet horizontally distant from the Fénelon shaft, which serves as an upcast for the St. Louis pit. Ventilation is natural, but sometimes (in very hot weather) a furnace is lighted close to

the Fénelon shaft. Although the workings are not fiery, the use of safety-lamps and safety-explosives is compulsory in certain districts of the mine, where slight traces of fire-damp were met with in the course of forewinning. At the point where the workings intersect an unworkable nameless seam (which has a good gritstone-roof, some 25 feet thick), a sufficient space had been excavated to accommodate two chambers, walled and vaulted throughout with masonry, each 6½ feet broad and of a combined depth of 10 feet. The first chamber was closed off from the workings by an oaken door, about 2 inches thick, and the second chamber (the store proper) was shut off from the first in the same way. The atmospheric conditions (as to dryness, temperature, etc.), were such as to preclude any deteriorating or dangerous effect on the dynamite. At the time of the disaster, the contents of the store were: 293 pounds of dynamite and 253 pounds of grisoutine. Both explosives had been received into store in the preceding September, and the inference is that they were manufactured and transported from the factory to the colliery during the hot months.

No actual witness of the accident survived to relate how it happened. The store and its contents, doors and walls were pulverized. At bank, a sharp detonation was heard, and a long tongue of reddish flame shot up from the pit-mouth, giving place almost immediately to clouds of smoke.

After examining the various hypotheses as to the cause of the catastrophe, the author concludes that the man whose duty it was to distribute dynamite-cartridges to the shot-firers was using a naked lamp, and that by some means this ignited one of the cartridges. He had, that morning, taken down the pit, lighted, both a safety-lamp and an ordinary lamp, the latter of which he was accustomed to use on such repairing work as filled up the time that was not devoted to his duties in the explosive-store. It seems fairly certain that neither fire-damp nor coal-dust played any part in the catastrophe. The poisonous gases resulting from the explosion were so rapidly diluted by the air-current (350 cubic feet per second) passing through the mine, that none of the deaths are properly assignable to mere asphyxiation by such gases. L. L. B.

SINKING WITH THE PATTBERG PERCUSSION SHAFT-DRILL AT THE RHEINPREUSSEN COLLIERY.

Das Stossbohrverfahren von Pattberg und seine Anwendung beim Abteufen der Schächte IV und V der Zeche Rheinpreussen in lockerem Gebirge. By L. Hoffmann. *Glückauf*, 1902, *vol. xxxviii., pages* 553-556, *with* 1 *illustration in the text and* 1 *plate.*

In the Pattberg drill, the reciprocating movement of the tool is effected by an oscillating drum, instead of by a lever. The drill-head is made of wrought iron, shaped like an inverted cone, and pierced by a tubular hole from either side, to the centre, where they communicate with a vertical pipe, connected to the hollow drill-rods. A number of tubes, at right angles to each hole, deliver the flushing-water to channels in the steel-cutters. All the stays and struts of the drill-head are of wood.

The first drill used in sinking at the Rheinpreussen colliery measured 21 feet in diameter, 27 feet in height, and weighed 9 tons; but these dimensions were reduced to 19 feet in diameter and 7½ tons in weight as the depth increased.

The mud from the shaft-bottom is raised by two air-lift pumps mounted

on the drill-rods, compressed air being forced down an air-pipe from the surface and discharged near the bottom, into a concentric inner pipe forming the upcast for the flushing-water and mud.

Vertical guides for the drill-rods are erected in the head-frame, and the cable is passed over the head-pulley to a drum which is oscillated by a pitman driven from the crank-shaft of the engine. Partial balancing of the weight of the drill is effected by steam-pressure on a plunger connected to the oscillating drum, and an engine of about 40 horsepower is required. The rope is run out as the sinking proceeds by a special gear, which enables it to run off the oscillating drum without altering the stroke of the pitman. The total weight of the drilling-rods and pipes is 90 pounds per running foot, and the drill makes 50 to 60 strokes per minute, the length of the stroke being 7 to 8 inches. During a complete revolution, the drill is shifted 20 to 60 times according to the hardness of the rock.

In sinking at the Rheinpreussen colliery the preliminary work in loose ground was performed by an elevator, to a depth of 55 feet. The shaft-bottom (30 feet in diameter) was then plugged with 10 feet of concrete. Through this a new shaft, 20 feet in diameter, was sunk, lined with an outer ring of tubbing and an inner wall of brickwork, the tubbing-joints being packed with asbestos instead of lead. This shaft, however, could not be forced lower than 200 feet, and a second shaft 19½ feet in diameter (lined with 2½ to 3 inches tubbing) was constructed.

The average rate of sinking with the Pattberg drill is 3¾ feet per diem, with a maximum speed of 16½ feet on two successive days. C. S.

SINKING IN UPPER SILESIA.

Das Schachtabteufen des Junghannschachtes II auf der Dubenskogrube in Oberschlesien. *By* E. LANGER. *Glückauf*, 1902, *vol. xxxviii., pages* 193-195, *with* 3 *illustrations in the text.*

In sinking this shaft, round a bore-hole, to drain off the water into existing workings below, the dry method had to be abandoned at a depth of 33 feet (10 metres) and replaced by sinking tubbings, 19 feet (5·77 metres) in internal diameter, forced down by hydraulic pressure. However, on reaching the solid Coal-measures at a depth of 150 feet (45·7 metres) the shoe could not be driven further; and as, owing to the dip of the strata, one side of the shoe was still in water-bearing sand, it was impossible to keep out the water while clearing out the hard rock under the shoe to the necessary additional depth of about 10 feet (3 metres).

To overcome this difficulty, 104 bore-holes, 10 inches in diameter, were drilled to the desired depth in two concentric circles close inside the tubbing, the holes being arranged to slant outwards. This work was performed by two short-stroke, water-flush percussion-drills, mounted on a movable platform. As, however, the water-flush failed to raise the boring-mud to the surface, dry drills and balers had to be used; and even this method met with but little success, a number of ribs of stone being encountered, which had to be pulverized by means of X drills. After the drilling of these holes had formed an annular channel for the sinking shoe, pressure was applied to the sinking-shaft, the weight of which had been increased to 3,000 tons. But, as the shoe could not be forced down, the shaft-bottom was examined by divers, who reported that the shoe was

broken on one side, and that two segments of the tubbing were cracked and bent outwards, possibly on account of insufficient strength. The shaft had therefore to be abandoned, pending the selection of a method for completing it, whether by putting in a concrete plug and fresh sinking-tubbing or otherwise. C. S.

DRAINAGE OF A SHAFT WHILE BEING SUNK IN AUSTRIA.

(1) *Die Wasserhaltung beim Abteufen des Schöllerschachtes in Libuschin bei Kladno.* *By* VICTOR KADAINKA. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix.*, *pages* 561-564, *and* 1 *plate.*

(2) *Verfahren und Einrichtung, beim Abteufen von Schächten ein vorhandenes Bohrloch behufs ungestörter Wasserlosung intact zu erhalten.* *By* EDUARD GROSSE *and* JOSEF SRB. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix.*, *pages* 669-670.

The writer describes the draining of a shaft in the Libuschin mine, by means of a bore-hole 6 inches in diameter, intersecting another shaft from which it is 7,500 feet distant. The success which has attended this method of draining has obviated the necessity for pumping, caused by the influx of water.

The sandstone of the Carboniferous strata, of which the Kladno coal-field consists, holds so much water that, when boring for blasting, a feeder is often tapped yielding hundreds of gallons per minute. To utilize a bore-hole, to carry off water, is not a new idea, but it is not so simple as at first sight appears. If the top of the bore-hole be cut level with the surface of the ground, so that the water may run into it easily, pieces of earth or rock may also get in and clog it up. After blasting, the *débris* must be cleared from the mouth of the hole, while the water is rising over it, and sometimes the force of the explosion destroys the hole. Pumping out the water is a laborious process, but if anything goes wrong the pump can be taken out and repaired, though if a bore-hole be stopped up, it cannot be reached until the water has been drawn off.

The difficulties of draining the shaft at Kladno were so great that they were only partly overcome by boring a hole into an adjoining shaft. To keep the mouth clear of *débris*, the top of the pipe was allowed to project 3 feet above the ground, and the water was run into it by means of a siphon-pipe, lowered, from a platform above, into the bore-hole by a hand-winch. A hose is inserted into the funnel of the siphon, a valve at the bottom closed, and air is admitted at the top. As soon as the water comes out at the air-cock, the flow is regulated, and the siphon begins to act. Before blasting, it is drawn out of the way by the hand-winch. To prevent the bore-hole from being injured when blasting, a wooden pipe was at first placed over it, but as a blasting-charge takes effect chiefly in the surrounding rock, it is the part of the bore-hole belowground which must be protected. Just before blasting, therefore, when the siphon was removed, a steel-pipe about 23 feet long and 4¼ inches in diameter was inserted into the bore-hole, the length of this pipe extending sufficiently below the blasting zone to preserve it from injury. The projection of the pipe above the ground still caused difficulty, because a piece of rock might fall upon it; this danger was avoided by attaching the upper part to one of the shaft-frames, and placing a cover over it. It was a curious circumstance that every time the siphon was removed, ice was found underneath it, although

the temperature was about 59° Fahr. As the water rushing into the bore-hole never completely fills it, a vacuum is produced, and this acting upon the damp air from the shaft, when it gets inside, instantly converts it into ice, in the same way as the exhaust of an air-compressing engine.

To obviate the inconvenience of using two pieces of apparatus, the lining pipe and the siphon, the writer combined them into one. Over the lining pipe, a wrought-iron pipe, with two bends, was fixed, the other end of which being fitted with a suction-hose, the same effect as that of a siphon was produced. To start the siphon a 1 inch hole is made in the bore-hole pipe, just above the water-line, and as soon as the water flowing in produces a vacuum, the hole is closed, and the siphon acts automatically. By carrying off the water in this way, the shaft at Kladno, which was 18 feet in diameter, was sunk without difficulty, at an average rate of 116 feet per month.

In 1899, Messrs. E. Grosse and J. Srb introduced an invention with the same object, namely to drain the water from a shaft by a bore-hole. The only difference between their apparatus and the one used at Kladno is in the method of keeping the bore-hole clear. A protecting pipe is inserted into it, and fitted with an inner pipe and a strainer, through which the water passes, and is thus prevented from carrying foreign substances with it. The protecting pipe can be raised and lowered at will. In other respects the two inventions are alike. E. M. D.

LINING A MINE ROADWAY WITH CONCRETE.

Charbonnage de Marcinelle-Nord : Puits No. 11 : Revêtement en Béton d'un Bouveau. By — GHYSEN. *Annales des Mines de Belgique*, 1902, *vol. vii., pages* 762-768, *with* 4 *figures in the text.*

A cross-measure drift, at the 2,900 feet level, was subject to violent pressure. The first supports used were strong bars and posts set 2 feet apart, but these could not resist the pressure, which was exerted in all directions. It was retimbered in the same way with the same result. A second renewal of the timbering was made with the sets 8 inches apart, but in 6 weeks this also required renewal. Double timbering was then resorted to, each setting being strengthened on the inside by two upright posts supporting stretchers abutting against a bar placed under the centre of the main bars and at right angles to them. This strong timbering maintained the roof for 3 months before breaking; a month later the road was impracticable, and it was decided to concrete it.

The trial was made on a length of 90 feet. The section of the drift after retimbering was 9 feet 8 inches under the bars and 9 feet 2 inches wide at the floor, the sides being made as vertical as possible. The timber-settings were very strong and spaced 3 feet apart, with poling and faggots over the bars and behind the posts. This retimbering was done for a length of 33 feet, and this was at once concreted before the pressure had time to break the timber.

The concreted section of the drift was 8 feet 2 inches high by 5 feet 11 inches at the widest part, and was egg-shaped with a flattened bottom. The minimum thickness of the concrete was 16 inches, save at the centre of the invert where it was 14 inches. The template was made in 4 pieces, two for the sides and two for the upper semicircular portion. The method

of inserting the concrete and its composition are fully described. The cost per running foot was as follows:—Labour, £1 2s.; material, 15s.; a total of £1 17s.

The drift had been finished for more than 7 months, and no deformation nor fissures were observable. Considering that the timbering and four re-timberings had cost not less than £3 per foot, the cost of concreting could not be considered prohibitive. W. N. A.

RAPID TUNNEL-DRIVING.

Driving the Newhouse Tunnel. *By* H. Foster Bain. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 552-553, *with* 3 *illustrations in the text.*

The Newhouse tunnel* at Idaho Springs, Colorado, is now driven 12,860 feet, and six mining companies are already at work on various veins cut by the drift. The rate of driving the tunnel has been materially accelerated: previously, the best record obtained was 160 feet per month, but recently it had made more than 280 feet in single months, whilst in February, 1902, the drift advanced 268 feet. Better records have been made elsewhere, but not in rock of similar character. For steady cross-cut work in granite-gneiss and schist with the dip away from the heading, and where the headings never break beyond the holes, the record is excellent.

After describing the plant and the daily routine of work, the writer states that the rapidity of the driving is due to three causes:—(1) High-pressure air; (2) the use of the Water-Leyner drill for back holes; and (3) the adoption of the premium basis of payment.

For drilling purposes, the air is compressed to 160 pounds per square inch. It has been worked up to this, in steps of 10 pounds, from an initial pressure of 110 pounds. Miners accustomed to pressures of 60 or 80 pounds have little idea how to handle high-pressure air; and it has been necessary not only to train the men, accustoming them gradually to using the high-pressure air, but also to reconstruct the drills so that they would stand it.

The Water-Leyner drill does its work satisfactorily, and the current of water running through the steel-rods keeps the bit cool and in temper, and removes the *débris* perfectly. Without the Water-Leyner drill it was found impossible to drill 10 feet back-holes as is now done daily. The best proof, perhaps, of its economy is the fact that in the month it was introduced, the air-pressure at the same time being raised 10 pounds, the footage rose 20 feet, a gain which has never been lost. There is, of course, a greater breakage at the higher pressure, but the breakage per foot is not more: 400 sharpened drills and a full supply of duplicate parts are constantly kept on hand, so that no time is lost when a part does break.

The third important element in the rapid and steady progress is the premium system. A bonus of £1 5s. (6 dollars) per foot is paid each month for all ground broken over the 160 feet formerly broken, and it is apportioned among all the men who work at the breast. This bonus brings up the wages of the drill-crew from 12s. 6d. (3 dollars) to about 16s. 8d. (4 dollars) per day, and increases the wages of the others by 1s. 7d. to 2s. 3d. (37½ to 55 cents) per day per man. While this premium now amounts to upwards of £100 (500 dollars) per month, the management

* *Trans. Inst. M.E.*, 1899, vol. xviii., page 516.

consider that the money so invested yields larger returns than that spent in any other direction. The men willingly work hard and, when necessary, long hours, rather than lose a round.

For the year ending August 31st, 1900, the total average cost per foot was, including all expenses, £6 (28·8 dollars); or a breaking cost, excluding the cost of permanent track, equipment, etc., of £4 9s. (21·45 dollars) per foot. During the same year, the tunnel advanced 2,760 feet, and last year the annual footage rose to 2,925 feet. X. Y. Z.

THE ASPEN TUNNEL.

The Aspen Tunnel. By A. W. CLAPP. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 519-520, *with* 3 *illustrations in the text.*

The completion of the great Aspen tunnel, a part of the cut-off from Leroy to Bear river, on the Wyoming division of the Union Pacific Railroad, has settled a puzzling engineering problem. Leaving Leroy, the new line follows the historic Mormon Pioneer Valley for 11¼ miles to Aspen tunnel, which pierces Aspen ridge, one of the eastern foot-hills of the Wasatch Range. Owing to the peculiar difficulties encountered, the construction of the tunnel is of singular interest. In the spring of 1899, the east and west headings were opened. In August of the same year, about midway between the portals, a shaft was sunk to a depth of 300 feet, with the intention of driving the tunnel in both directions from the shaft. This idea had to be abandoned, on account of the large amount of water encountered; besides which, a strong flow of mineral oil was found which mingled with the water. It was not at first thought that this carried any danger, but an explosion occurred in December, 1899, killing 3 men. Preparations were made to draw off and store the oil, but afterwards this course was abandoned, and the working in the shaft discontinued. At the present time, the oil forms a coating of about 2 inches on all water pumped from the tunnel.

After the abandonment of the shaft, excavation was pushed from the ends only. The method was as follows:—A heading was driven by power-drills, 30 feet above grade, for a distance of 16 feet with a diameter of 6 feet, at each side, leaving a core. The core was then removed by hand-labour. Following this operation, the flooring was removed until the proper grade was reached, so as to admit the steam-shovel. One of these shovels was employed at each end, and their capacity was such that as much material was removed in 3 hours as an entire gang of men could remove in 3 days. Following the usual rough timbering, the plumb-timbers of Oregon pine, 12 inches by 10 inches, were put in. When these had been firmly placed and temporarily braced, steel caps, 16 feet by 6 inches by 6 inches, were raised into position forming the arch of the tunnel. The first lift of concrete was then put in where the nature of the ground required it, which was, in fact, for a distance of 500 feet near the middle of the tunnel. This was followed by three other lifts until the entire surface was covered with concrete.

In the construction of the tunnel, three distinct formations of ground were encountered:—The rocky ground was bored by Burley drills and little difficulty was met. Then came shale, which was easily removed by the steam-shovels. Five hundred feet from the western end, however, the real

difficulties of the work commenced. The ground here was like a pot of yeast, or might be likened to the asphalt-beds of Trinidad on a small scale. As soon as air was admitted to the tunnel, it swelled like quicklime. The writer was shown an instance:—A section of ground, 4 feet square, was uncovered to a depth of 1 foot. In 10 minutes, the excavated ground was not merely level but had risen 14 to 16 inches above the contiguous earth. Such a pressure was difficult to overcome. It was thought that girders, 16 inches by 6 inches, would be sufficient, but they were bent like wire as soon as erected, and timbers, 12 inches square, were literally reduced into kindling wood. So sudden was the action of the ground that the men had to run for their lives from a spot in the tunnel where Oregon pine beams, 12 inches square, had just been placed. The effect was like an explosion, the ground swelling from both the bottom and the sides, and entirely closing up the tunnel. A successful result has only been achieved by means of steel rails, 96 pounds per yard laid close together, and covered with 6 feet of Portland cement.

The writer considers that the engineering work represented by the Aspen tunnel scheme would have been absolutely impossible a few years ago. The steam-shovel has been an important factor in the work of reducing grades and filling gulches. Its introduction into tunnel-construction is something new, and has made such achievements as the Aspen tunnel possible.

X. Y. Z.

HIGH-PRESSURE WINDING-ENGINE.

La Machine d'Extraction du Puits Saint-Dominique: Considérations et Expériences sur son Fonctionnement. *By* — RODDE. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 158-162, *and* 1 *plate.*

When erecting a new winding-engine it was thought desirable to reduce the steam-consumption to a minimum, while at the same time preserving the faculty of raising one loaded cage without its being balanced by the other. The three-decked cages carry two tubs on a deck; and the flat manilla-fibre ropes, wound on pulleys, are practically balanced when raising coal. As the caging operations have to be effected by the engine, it was also required that it should be able to let down loads by reducing the speed, by limiting the pressure in the cylinders, the reversing lever being placed as if used for raising a load and the regulator closed. Such arrangements, which had already been adopted at the colliery, also facilitate the caging operations by reducing the number of times that the engine is reversed. As the mean moment to be developed in winding with two cages has been found to be one-third that with one cage only, the problem was to reduce by two-thirds the power of the engine economically, and without complicating the numerous caging operations; and consequently compound engines were excluded, which are wanting in elasticity unless high-pressure steam be frequently admitted into the large cylinder.

Accordingly, two single-cylinder engines, coupled at an angle of 90 degrees on the drum-shaft, were adopted; and, for rendering them economical, the expansion (variable by the governor) was fixed sufficiently high for the regular speed to be attained without throttling the steam. Inasmuch as condensation could not be employed, the higher pressure was fixed at 114 pounds per square inch (8 kilogrammes per square centimetre), in order that at the end of the expansion-period the pressure might be at least equal to the counter-pressure during the exhaust. As the caging operations are

very frequent, the space between th regulator and the admission-valves is often filled with steam, to be again evacuated; and this space was reduced to a minimum by arranging a regulating-valve for each cylinder, both being worked by the same lever.

The cylinders are 31½ inches (80 centimetres) in diameter, with a stroke of 5 feet 3 inches (1·6 metres). The engine was calculated for winding from a depth of 2,300 feet (700 metres) with a steam-pressure of 114 pounds per square inch (8 kilogrammes per square centimetre); but the present depth is only 1,276 feet (389 metres), while the ports are calculated for a pressure of 142 pounds per square inch (10 kilogrammes per square centimetre).

Trials extending over 24 hours showed that the useful work per 2·2 pounds (1 kilogramme) of steam during 24 hours was 79 foot-pounds (10·917 kilogrammetres) and during the period of winding 92 foot-pounds (12·706 kilogrammetres).

While the useful load in winding coal is 3 tons, letting down 6 tubs of gob-material constitutes a load of 4·2 tons; and a comparison of the diagrams in the two cases shows that the work absorbed by the engine in the latter is about equal in regularity to the work given out in the former, while the engine is not strained in an appreciably greater degree. J. W. P.

ACCIDENTS FROM FALLS OF STONE AND COAL IN UPPER SILESIAN COLLIERIES.

Stein- und Kohlenfall-Verunglückungen auf den oberschlesischen Steinkohlengruben. By — GEISENHEIMER. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1903, *vol. li., Abhandlungen, pages* 115-140, *with* 15 *figures in the text.*

This memoir embodies the results of all official enquiries, conducted during the period between October, 1901 and February, 1902, into the 110 falls of stone and coal that occurred in the collieries of Upper Silesia. The causes of these accidents are considered first of all: in 38 cases, the fall was sudden, no premonitory signs having been observed. In 12 other cases, signs of pressure or crush were apparent before the disaster happened. In 3 cases, stone or coal was loosened by tapping or hammering. In no less than 33 cases, the stone or coal was caused to break down in course of winning, and 18 accidents occurred in process of timbering. The total loss of life amounted to 31, and in addition 85 persons were more or less severely injured. The greatest number of falls occurred in the group of measures which includes the Einsiedel seams: these have apparently a very bad roof. The other group of measures, notorious for the frequencies of falls, includes the Reden seams, and here a notable proportion of accidents took place very suddenly, without any warning sign having been detected.

The foregoing facts are elucidated by a great number of analytical and synoptical tables; and the author points out that, in order to diminish the risk of falls, workers in mines should be compelled to observe the necessary precautions even under the most favourable circumstances. Where the greatest danger might have been looked for fewest accidents occurred, simply because proper precautions had been taken. He suggests certain additional regulations in regard to timbering, etc., in the collieries of the district under notice, the main point being that less latitude should be left to the discretion of the ordinary pitmen, and more responsibility placed on the overmen, etc. L. L. B.

ELECTRIC WINDING-ENGINES.

Electric Hoists on the Comstock. *By* LEON M. HALL. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 140-141, *with* 2 *illustrations in the text.*

With the advent of electricity on the Comstock, it became necessary to take up the problem of hoisting from considerable depths, and after a thorough investigation of the then existing electric hoisting machinery, it was evident that in order to meet the conditions of power and service something must be had radically different from the usual run of such machinery. The writer finally decided on the system described in the article, and installed a continuous-rope electric hoist, driven by means of a variable-speed, three-phase induction-motor.

The power is purchased upon a continuous-rate basis, the amount being fixed by a peak-load of 2 minutes' duration. Under these conditions, it has been the aim to secure a hoist that will operate at the highest possible efficiency, and at the same time affect the regulation of the general system as slightly as is consistent with good service. To meet the condition of high efficiency, it is evident that the motor should work continuously at or near full load, and be specially designed for the work which it has to perform. For a continuous full-load condition, the work must be constant at all points in the lift, and the nearest possible approach to this was secured by the adoption of the continuous-rope or balanced system, where the load is reduced to the weight of the rock alone. Then, to secure the necessary variation in speed, an induction-motor with a non-induction resistance in both primary and secondary was developed, the resistance being varied by the introduction of a modified form of the ordinary street-car controller.

The results with regard to efficiency are stated to be remarkably good—75 per cent. efficiency having been obtained under the severest tests. The writer points out, however, that the advantage of this class of hoist consists not only in its high efficiency, but also in its large capacity compared with the size of the motor in use. X. Y. Z.

THE USE OF CENTRIFUGAL GOVERNORS ON WINDING-ENGINES.

Sur l'Emploi des Régulateurs à Force Centrifuge aux Machines d'Extraction à Détente Variable. *By* CHARLES FRANÇOIS. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut*, 1902, *vol. xii., pages* 214-271, *with* 29 *figures in the text.*

In winding-engines, steam-distribution with expansion variable by the governor is more and more tending to supersede those with full pressure or with fixed expansion; and theoretically an excellent utilization of the steam should be obtained, as the volume admitted at each stroke is exactly proportioned to the work to be performed, while the engine ought to run with perfect regularity. As to the first of these points, the winding-engines to which expansive working has been applied have realized a great saving of steam and therefore of fuel.

The case is, however, by no means the same as to the second point; and many still are the engines in which the working has been found very unsatisfactory, owing to great variations of speed. The sagging and vibration of the ropes soon required suppression of the governor's action on the expansion-gear, and transformation of the engine into one with four distributing

valves with full admission, this change being all the more necessary as safety is of far greater importance than economy of working.

If it is difficult to prove that the breakage of ropes may be caused directly and solely by variations of speed, it is no less true that the vibrations which they set up bring the rope into violent contact with the guides and buntons, and even with the sides of narrow shafts. The deterioration resulting from the repeated shocks at length inevitably reduces the rope's resistance; and in the case of steel-wire it is now admitted that vibration alone greatly impairs the strength. Lastly, it may be readily supposed that, in the presence of this diminished resistance, an unusual effort or unfavourable conditions of working may bring about a breakage, arising from defective working of the winding-engine.

The requirements for a good winding-engine with expansion variable by the governor are:—(1) The steam-admission should be determined in accordance with the work to be done by the engine, shocks and variations of speed being avoided during this transitory period. (2) The expansive working should be obtained after a minimum number of cylinders-full of steam without cut-off. (3) During the lift, the motive work, or power, should follow the variations of the resistance while maintaining the most constant possible speed.

The author examines the conditions for satisfying these three requirements, and arrives at the conclusion that the ordinary centrifugal governor for regulating the expansion of a winding-engine is quite incapable of performing that duty, and can only give the motor a very irregular speed of working. Passing from full admission to the maximum expansion, this working is characterized by great variation of motive effort, manifesting itself in sagging and vibration of the ropes, so much the more marked as the distance between the engine and the pulleys is more considerable.

The writer then examines the modifications that can remedy this faulty working of the governor, and they may be classed under three heads:—(*a*) Addition of a brake, depending on the speed of the engine; (*b*) limitation of the travel of the slide; and (*c*) modification of the isochronism of the expansion-gear, of which actual examples are given, with their effect or results. The writer arrives at the conclusion, that each case must be studied on its own merits, and the solution sought by trials and modifications, which are always very simple, while the time spent in this study is amply repaid by the saving of fuel effected. J. W. P.

WINDING BY GAS-ENGINES.

Gas-engines on the Pacific Coast. *By* G. P. GRIMSLEY. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxi., page* 756, *with* 1 *illustration in the text.*

Gas-engines use fuel only at the actual time of working; and mine-hoisting, being work of a more or less intermittent character, may be effected by gas-engines with an economy of fuel. For the past five years, these engines have been built of the vertical type, those from 10 to 60 horsepower having two, and those over 60 horsepower having four cylinders. The double cylinder gives a working impulse on every revolution, thus hoisting the load without jerk. One of the largest Union Gas hoisting engines is now in use on the 400 feet level of the Yellow Aster Mine, Randsberg, California,

and is a four-cylinder double-drum hoist of 130 horsepower. The engine and hoist occupy a space 14 feet by 17 feet, and 6½ feet high, with the levers all brought to one platform. The engine is set 800 feet within the tunnel, and connected with the distillate-tank outside by a 1½ inches supply-pipe. Other gas-hoists are at work in the same mine, and the Pacific Coast Borax Company, near Daggett, California, is using eight of these gas-engines, five of which are driving hoists.

All the Union hoisting-engines are equipped with sensitive governors, which are specially designed to graduate the charge and admit it to the cylinder in proportion to the load. This is accomplished by the use of two valves requiring only one-half the movement of an ordinary single valve-governor. All large engines are fitted with self-starter gear, so that they start as readily as steam-engines. It is claimed that the expense of running these engines on gasoline or distillate varies from ⅛ gallon per horsepower-hour in small engines to $\frac{1}{10}$ gallon in the larger engines.

X. Y. Z.

SEMI-AUTOMATIC BARRIERS FOR SHAFTS AND LANDINGS.

Barrières semi-automatiques du Puits Saint-Dominique. *By* — BOUCHUT. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 162-164, *and* 1 *plate.*

The barrier was required to open simultaneously at the front and back of the landing in obedience to a slight effort by the banksman; and, in the absence of this effort, only to remain open when the cage is at the landing, but to close directly the cage descends the shaft or rises towards the pulleys.

Two barriers of perforated sheet-iron, sliding in vertical guides, are connected by wire-ropes with pulleys at the end of a shaft, which carries a third pulley of half the diameter, connected by a rope to the piston-rod of a single-acting compressed-air cylinder, a counterweight on this piston-rod partly balancing the weight of the barriers. When the piston descends in the cylinder the barriers rise; and they are kept raised by an arrangement consisting of a cam and a spring-hook, entering a recess in the periphery of a disc, keyed on the pulley-shaft. When contact ceases between the cage and the cam, the latter cants and releases the hook, then the barrier descends owing to its weight being greater than that of the piston, its rod and counterweight.

The following are the principal advantages of this arrangement:—(1) As the barrier is not moved by the cage, there is less shock and the cost of maintenance is slight, the barriers put in at the Saint Dominique shaft in January, 1902, having required no repairs, and being still in thorough order. (2) The barriers may be placed in front of the openings in the landing for the cages to pass, so that a complete closing of the shaft is obtained. (3) The barrier lowers directly the cage leaves the landing, upwards or downwards, and so there is no occasion to fear an untimely opening of the shaft, when the cage is drawn above the landing. (4) The rise of the barriers is limited, and there is no occasion to guide them as high as the safety-buntons. (5) Lastly, the cage passes these barriers without opening them.

J. W. P.

COMPRESSED-AIR LOCOMOTIVES FOR MINE-HAULAGE.

Compressed-air Haulage. *By* ROBERT PEELE. *Mines and Minerals*, 1902, *vol. xxii., pages* 562-564, *with* 3 *illustrations in the text.*

The author describes the construction and operation of compressed-air locomotives and the arrangement of such systems of haulage. He favours the adoption of compressed air as a motive power, rather than steam or electricity. The compressed-air locomotive solves the problem of secondary haulage in moderately thick seams which are practically level. It can enter all parts of the workings where track is laid, even far beyond the limits of the pipe-line; whereas the electric locomotive is dependent on wiring for every foot of advance. The air-locomotive can thus run its train of cars between the shaft and landings, and also enter the rooms and breasts to bring out the single cars required to make up the train.

At the Empire gold-mine, Grass Valley, California, a small air-locomotive has been in use for four years on the 2,000 feet level. It is one of the Rix type, and runs a train comprizing five cars each carrying 1 ton. The round trip is 5,000 feet, the tank being 3 feet in diameter by 4 feet long, and carrying a pressure of 500 pounds per square inch. The dimensions over all are:—Length, 60 inches; width, 30 inches; height, 52 inches. Gauge of track, 18 inches. Instead of ordinary engines, a pair of Dake rectangular piston-engines are used, they are very simple and compact, and have no dead centre.

The Peerless Colliery, Vivian, West Virginia, has two air-locomotives which have run satisfactorily since 1896. They are of the H.K. Porter type and of the following dimensions:—Length, 126 inches; width, 68 inches; height, 53 inches; four driving-wheels, 23 inches in diameter. The gaug is 44 inches. The weight is 10,000 pounds, and the trains consist of six cars, each loaded car weighing 8,500 pounds. The capacity of the main storage tank is 47 cubic feet, carrying a pressure of 535 pounds per square inch; the cylinders 5 by 10 inches; and charging time, 20 seconds. The working pressure in the auxiliary reservoir is 125 pounds. The main pipe-line is 3 inches in diameter, its total capacity is that of the locomotive-tank, and it carries a pressure of 715 pounds per square inch. These locomotives are designed to work on curves of as little as 15 feet radius, they render mule haulage unnecessary, as they enter the rooms themselves, and make up their own trains. The cost of each locomotive is about £375.

A larger locomotive has been running for five years at the Wilson colliery of the Delaware and Hudson Coal Company. It has three pairs of 26 inches connected driving-wheels, and two tanks with a total capacity of 160 cubic feet, carrying a pressure of 600 pounds per square inch. The pipe-line is 4,100 feet long, carries a pressure of 700 pounds per square inch, and has a capacity seven times as great as that of the locomotive-tanks. In the auxiliary reservoir, the pressure is reduced to 125 pounds. Reheating is employed. The trains regularly hauled consist of thirty cars, each weighing, loaded, 5,850 pounds, although the locomotive has a capacity of fifty cars. The grades vary from 1 per cent. against to 1 per cent. in favour of the load. The round trip of 8,200 feet is performed in 16 minutes, and the haulage-cost per ton-mile is $\frac{3}{4}$ penny (1½ cents).

The Anaconda copper-mine, Montana, has air-locomotives as follow:—Height, 58 inches; width, 58 inches; length over all, 124½ inches; four driving-wheels, 23 inches in diameter; wheel-base, 3 feet, designed to work on curves of only 12 feet radius. The gauge is 18 inches. The

cylinders are 5 by 10 inches. The pressure in the main tank is 550 pounds; in the auxiliary tank, 125 pounds per square inch. The capacity of the main tank is 47 cubic feet. The total weight is 10,000 pounds. The round trip is 2,400 feet, the train comprizes six cars, each when loaded, weighing 3,450 pounds. The track is nearly level. The locomotive is built to make two round trips with cold air without re-charging, but by re-heating with hot water, three or four round trips per charge can be made. This group of mines has nine compressed-air locomotives at work. X. Y. Z.

THE NEW WOLF SAFETY-LAMP.

Commission du Grisou, Sur une Nouvelle Lampe de Sûreté à Essence: Système Wolf à introduction d'Air par le Bas, Rallumeur à Friction et Fermeture Magnétique. By G. CHESNEAU. *Annales des Mines*, 1901, *series* 9, *vol. xx., pages* 493-504, *with* 4 *figures in the text.*

This is a new benzine-lamp, provided with a friction-lighter, magnetic lock, and admitting the air from below. The French Fire-damp Commission, having been requested by the Minister of Public Works to report upon the lamp, state that it presents all the necessary conditions of security for use in fiery mines.

The descriptive portion of the report consists mainly of diagrams, which are apparently considered more instructive than a lengthy verbal description. Proceeding then to recount the tests to which they submitted the lamp, the Commissioners state that they were unable to find any defect in the magnetic lock or to make it work defectively in any way. It cannot be "started" or dislocated by a violent jar, as was formerly possible with magnetic locks.

The illuminating efficiency of the lamp is not greatly superior to that of good oil-lamps at the beginning of a shift, but it has the supreme advantage of remaining practically constant, as the wick is not carbonized, and the supply is continuous so long as there is any benzine in the reservoir.

Provided with its double gauze, and also with a single gauze, the lamp was tried in explosive mixtures of air and gas which were travelling at a high speed, with very satisfactory results as regards its immunity from explosion.

The experiments made in the matter of relighting showed the great superiority, as to safety, of the Wolf friction-fuze over the Seippel percussion-fuze. L. L. B.

THE DETERMINATION OF FIRE-DAMP IN MINES.

Des Observations continues à instituer pour la Détermination des Quantités de Grisou dégagées dans une Mine. By PAUL HABETS. *Bulletin de la Société Belge de Géologie, de Paléontologie et d'Hydrologie*, 1901, *vol. xv., Procès-verbaux, pages* 465-480.

One of the problems connected with the quantitative determination of fire-damp in mines is how to trace the influence of seismic movements on the presence (in more or less abundance) of the noxious gases.

The author first of all describes the general atmospheric conditions of a colliery, pointing out that it may be defined as a network of subterranean excavations which are being continually modified—are, so to say, in con-

tinuous motion. (He refers here to the opening up of new workings and the abandoning of old, blocked up partly or wholly by falls of rock or waste.) Moreover, in the usual course of events, the circulation of air in the mine, besides varying slowly with the temperatures, undergoes other changes more or less sudden and temporary. It is, then, in an unstable medium that pit-gas is evolved.

From the numerous experiments that have been made by various observers it may be concluded that fire-damp is unequally distributed within the mass of coal, or at any rate, that the permeability of the mass varies greatly from one point to another. It may be observed also that the so-called fieriest seams do not necessarily contain within themselves the most fire-damp, but they give off more than others. On the whole, the author would recommend the classification of fiery mines in Belgium on the basis of a comparison between the quantity of fire-damp evolved and the quantity of coal produced, quite independently of the conditions of ventilation.

It would be easy enough to determine the influence of microseismic disturbances on the normal evolution of gas in a fiery mine, if a fairly permanent increase in the quantity of gas evolved were to correspond to increased seismic activity, and could not be explained on any hypothesis connected with the ventilation or the working-conditions of the mines. But, unfortunately, the normal evolution of gas in fiery mines is complicated by abnormalities. Contorted portions of the seam, sudden thinnings or pinches-out, where the coal has been more or less crushed, give rise to an increased (often sudden and violent) evolution of gas the moment that they are reached in the course of winning. Such "outbursts" are notoriously common in some of the collieries near the southern border of the Belgian coal-field and in those of Bessèges in south-eastern France. They originate in masses of coal so dangerously permeable as to deserve the epithet "explosive," confined within the mass of the compact coal. Many engineers concur in asserting that the greatest danger from these is just when the air drawn out of the workings shows less than its average percentage of fire-damp: a high tenour of fire-damp in the return-airways is held to show that the seam is generally porous, is "bleeding" freely, and that therefore the presence of an explosive mass need not be feared. On the whole, we may conclude that microseismic energy has no influence on such instantaneous outbursts of fire-damp as those just mentioned: if it had any, such influence would be preventive rather than otherwise, as the conceivable dislocation of the compact coal would permit of a natural and slow draining away of the imprisoned gases.

The author discusses briefly the merits of various appliances now in use for determining the velocity and volume (percentage) of gases present in the air of a mine. He recommends for the measurement of the former Mr. Murgue's apparatus (or that of Mr. Fuchs), and for the measurement of the latter the Petit autocaptor, by means of which samples would be obtained for careful analysis in the laboratory. He recommends also the use of the Schultze automatic recorder.

In the discussion on this paper it was pointed out by Mr. Van den Broeck that the experimental enquiry as instituted by the Belgian Department of Mines would not include the systematic study of the evolution of fire-damp and the changes to be observed therein, and he and others urged that representations should be made to their government as to the importance of such an investigation. L. L. B.

GUGLIELMO FIRE-DAMP INDICATOR.

Description d'un Appareil Avertisseur de la Présence du Grisou, du Gaz d'Éclairage, ou de Vapeurs Inflammables dans l'Air. By G. GUGLIELMO. *Archives Néerlandaises des Sciences exactes et naturelles*, 1901, *series* 2, *vol. vi., pages* 555-562.

The indicator proposed by the author is a modification of the baroscope. This consists of a fairly sensitive balance, to the arms of which are suspended two bodies, which have in atmospheric air the same apparent weight but very different volumes—as for example, a hollow, hermetically-closed sphere of thin brass and a slab of massive brass or lead. Supposing the baroscope to be in equilibrium in atmospheric air, and that 1 per cent. of fire-damp mixes itself with the air, the pressure exerted on the hollow sphere will be decreased by 5 milligrammes for every litre of its cubic capacity. The sphere will thereupon lower its arm of the balance as if a weight of 5 milligrammes had been hung on it, and then by closing an electric circuit it can set one or more alarm-bells ringing. The instrument, which is of very simple and cheap construction, can be set up almost anywhere; and it can also be made portable, so that the miner could, for instance, carry it with him in exploring abandoned workings, etc.

In order to avoid the errors which might arise through differences of temperature and barometric pressure, the author, instead of closing hermetically the hollow sphere, allows it to open into the external atmosphere by a very long capillary tube. It is claimed that, in this way, thermometric and barometric changes produce no effect on the balance, while fire-damp could only penetrate very slowly within the sphere by diffusion through the long capillary tube, and therefore the value of the baroscope as an indicator is practically undiminished. Another method consists in fixing to the beam of the balance longitudinally a small thermometer which acts as a compensator.

L. L. B.

COLLIERY-EXPLOSION IN WEST VIRGINIA.

The Explosion at the Red-Ash Colliery, Fayette County, West Virginia. By W. N. PAGE. *Transactions of the American Institute of Mining Engineers*, 1900, *vol. xxx., pages* 854-863, *with* 1 *figure in the text.*

The Red Ash colliery was the scene, on March 9th, 1900, of an explosion by which some 50 men were killed or injured, and much property was damaged or destroyed. The colliery is a drift-mine, with entrance on a slope 500 feet above the south bank of the New river. It was ventilated by an exhaust-fan, driven by compressed air, and the workings were laid out for an excellent system of ventilation with an intake-airway of 75 square feet area.

On March 19th, when it was possible to re-enter the mine, the walls and roof of the main entry were found covered with white dust from the floor; farther in, the roof and sides were coated with coked dust; air-doors were found several hundred feet from their original position, etc. A curious reversal in the direction of the force of the explosion was observed, which was probably caused by a secondary explosion, either of gas, or of carbon monoxide produced by the reduction of carbon dioxide (CO_2) in passing over red-hot coke and forming carbon monoxide, which is a combustible (and when mixed with air before ignition, an explosive) gas.

The primary cause of the explosion was fire-damp on which the dust had little or no influence, though when the gas was once ignited it must have

played an important part by adding to the forces evolved. Fire-damp had been found within 4,000 feet of the entrance, but the presence of gas in dangerous quantities had not been fully realized, consequently some of the precautions for a highly gaseous mine were omitted. During a period when the fan was idle on the previous night, gas must have accumulated in the workings; and, on starting the fan in the morning, this accumulation became mixed with air and was travelling out along the return air-course when it was met by a naked light. A. W. G.

EXPLOSIONS IN PRUSSIAN COAL-MINES DURING 1900.

Mittheilungen über einige der bemerkenswerthesten Explosionen beim Preussischen Steinkohlenbergbau im Jahre 1900. ANON. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate,* 1901, *vol. xlix., Abhandlungen, pages* 473-476, *with* 2 *figures in the text.*

(1) On September 26th, 1900, between 5 and 6 a.m., an explosion took place at the Count Schwerin pit, Dortmund, whereby 2 men were killed, and 5 injured (2 seriously, 3 slightly). The disaster occurred at the No. 4 level (1,640 feet) of the bituminous President seam: this seam is about 5 feet thick, dips 40 degrees southward, and is far from fiery but extremely dusty. The regulations of May 24th, 1894, had prescribed the use of safety-cartridges when shots were being fired with guhr-dynamite, blasting gelatine, or gelatine-dynamite, and further that two should not be fired simultaneously. Disobedience to these regulations was the primary cause of the disaster.

Although it seems clear that the water-spraying apparatus was at work up to the moment when the shots were fired, this evidently did not suffice to lay properly all the coal-dust in the immediately-neighbouring workings. The notebook found on the body of one of the shot-firers proved that dynamite was being used, without the prescribed safety-cartridges. Two shots were fired all but simultaneously, and the dust created by the first, together with that whirled up from floor and sides, was ignited by the second shot. Fire-damp was not found in the workings, either before or after the explosion, and the possible intervention of fire-damp is therefore eliminated. The flame swept downward through the heading, extending 50 feet westward and 115 feet eastward to the cross-cut leading to the Tom seam. A film of dry coal-dust was found spread over everything at the original site of the explosion, and elsewhere traces of coke were found on the timbering, etc. The dynamic effects were inconsiderable, very little mechanical damage being done. The pit-ventilation remained on the whole undisturbed, so that rescue-work was not attended by any very considerable difficulties. The bodies showed but few burns, and the victims were evidently suffocated by the after-damp. A new regulation has been made, already in force in several other collieries, that master shot-firers are not to be allowed to take dynamite into the pit with them at the same time as safety-explosives.

(2) On the morning of October 12th, 1900, an explosion took place in the eastern district of the Minister-Stein Pit, United Stein and Hardenberg collieries, Dortmund, which resulted in the loss of 5 lives. The scene of the catastrophe was No. 3 north working of No. 1 North Seam, above the 1,023 feet level (lowest level). The coal-seam here varies in dip from the horizontal to 25 degrees, it is rather more than 4½ feet thick, bituminous,

and very fiery. The immediate roof is shale, which often falls in; above this is a sandy shale. The frequently-observed evolution of gas in the form of blowers, etc., is probably due to the occurrence of several small unworkable seams in the roof of No. 1 seam, which contain fire-damp in considerable quantity in a state of great tension. It was the custom in this pit, so soon as the proportion of fire-damp reached 1 per cent., to draw out the vitiated air by means of a system of pipes communicating with a ventilator driven by compressed air; if this failed to reduce the percentage of fire-damp, the portion of the workings thus affected was shut off by masonry-dams. No arrangements were made for water-spraying, as the seam showed but little tendency to dustiness.

In the night of the 9th to 10th of October, 1900, the presence of fire-damp in considerable quantities was observed. Work was suspended in the invaded portion of the pit, and the construction of a dam was started: this was all but completed just before the explosion took place, but the ventilating apparatus (pipes) had to be removed from the abandoned portion of the workings. 'It appears that notwithstanding distinct orders to the contrary, one of the 5 men employed on this work had climbed over the dam and placed his lamp upon it so as to see more distinctly. There was a rent in the wire-gauze of the lamp; and, in this way, the combustible gases accumulated in the vicinity, and driven forward by the eastward travelling ventilating current, were ignited. The dynamic effects of the explosion were of no great importance: brattices, etc., showed no trace of damage. It is thought that the natural dampness of the pit prevented the coal-dust from becoming the vehicle for the further spread of the explosion. No new regulations have been thought necessary. L. L. B.

EXPLOSIONS OF FIRE-DAMP AT THE PLUTO SHAFT, 1900.

Die Schlagwetterexplosionen auf den Plutoschächten in Wiesa am 13. November 1900. *By* FRIEDRICH OKORN. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 391-394, 405-408, 417-420, 434-436 *and* 443-447, *and* 3 *plates.*

On November 13th, 1900, two explosions took place at the Pluto shaft, about 4,000 feet from the main shaft of the Bruch coal-mine at Wiesa. In the first, at 2 p.m., 12 men were injured; in the second, just after 4 p.m., 18 men were killed and 7 injured. Among the dead were the manager, two mining engineers, and other officials. The cause of the double catastrophe was the ignition of carbon monoxide and of carburetted hydrogen gases.

An explosion had already occurred in November, 1894. Since then the mine had been enlarged and seven shafts sunk for winding, pumping and ventilation, at depths from 730 feet to 1,200 feet. The draining and ventilation of the mine were considered ample. There are more than 3½ miles of high-pressure air-pipes and 7½ miles of water-pipes. The Pluto shaft employs 650 miners and 306 men above ground, and 1,200 tons of coal are raised per 24 hours, in three 8 hours' shifts. Every three months, according to Government regulations, samples of the air are analysed at the public laboratory. The last analysis, made 2 months before the explosion took place, showed 12 per cent. of fire-damp and 14·9 of carbonic acid; and the writer calculates that about 440 cubic feet of fire-damp and carbonic acid are liberated per ton of coal in 24 hours. The average temperature in the shaft is 84 degrees Fahr. The length of ventilating pipes is about 5,250 feet.

The level where the catastrophe took place was laid out in October, 1900. Works in the neighbourhood had been closed, and notwithstanding all care to the contrary, the dividing pillars gave way, probably on account of blasting, 108 cartridges having been fired in 5 days. Cavities containing inflammable gases were then found in the old workings. On November 5th, this hole was closed by a wooden stopping, which appears to have remained intact, and the foul air to have percolated through the pillar itself. On the further side, another level had, in September, been found insecure, and shut off with a wall built of refuse or gob-stuff. Signs of spontaneous ignition soon appeared, and although water was played constantly upon the wall, a little blue flame could not be extinguished. On November 9th, the manager inspected the level, and found no active mischief. On November 10th, smoke was seen coming from the wall, a hole was made in it and well sprayed with water. Unfortunately, owing to repairs, the high-pressure water-pipe was out of use for the next 24 hours. The next day the wooden dam was observed to be hot, and there was a "bright glow" in the gob-wall, on which water was thrown by hand. On November 12th, it was decided to blast the level, wall it up, and abandon it. Early on the 13th, blasting was begun, and after the fifth shot smoke was observed coming from the wall. In the level, on the other side, no foul air was detected till this day, when a hole being made to test it, a lamp at the mouth was extinguished, and the opening immediately closed up. The main water-pipe, 6 inches in diameter, was by this time in working order, but owing to a misunderstanding the connection was not made till the 12th; and even then the pressure was insufficient. Three weeks before, a wall had been begun at the mouth of the level, but the work proceeded slowly for lack of material. On the 12th, seeing that the fire was increasing, the building of this wall was pushed on in hot haste; and on the 13th, the manager ordered the level to be wholly shut off, withdrew the men, and hurried up materials for finishing the wall, and bricking up the doors. Until this was done he did not quit the spot.

Twelve men were still engaged in the work, when at 2 p.m. the first explosion occurred. The still wet walls were thrown down, and all the men injured. Fortunately, owing to the change of shift, few miners were about. The explosion laid the level bare, and a bright flame was perceived, but no trace of fire-damp. It was immediately decided to withdraw to at least 600 feet from the spot, and three doors at this distance were walled up. The work was supervised by the manager, and carried out by a staff of volunteers. The two nearest doors had already been closed, the men were distributed between the three doors, and the manager was about to test for fire-damp, when the second explosion came. He and two of his assistants were instantly killed, and the rest attempted to escape. One of them managed to crawl to an air-pipe which being open, saved his life; others fled wildly from the scene, and were found dead or died later. Two dead bodies close to the door where the explosion took place were uninjured. All the men in the neighbourhood were thrown down, many doors shattered and most of the lights extinguished; while the level itself was completely wrecked. By 8 p.m., all the bodies had been recovered, and it was then decided to shut off, first with boards and afterwards with cement and mortar a large part of the mine round the scene of the explosion. The work was begun the same night, and carried on without intermission night and day.

The writer considers that the working conditions of the mine do not account for this explosion, since the ventilation was ample. The special danger of spontaneous ignition in a lignite-mine should have been kept in view, and guarded against, and the risk of an explosion carefully avoided until the level had been exhausted. This could have been done by utilizing water at high pressure, but several errors were committed. These were:—(1) Too much blasting; (2) lack of building-materials for the walls; (3) interruption of the water-supply; and (4) want of energy in pushing on the necessary works. It was a mistake to enlarge the level, when the supports were already exceedingly weak. More care ought also to have been exercised in keeping under the conflagration of the gob-stuff. At the moment when everything depended on rapidity in closing the hole, and smothering the fire, fresh blasting loosened the pillar, the wall became porous, and the air penetrating it fanned the flame. Even then, it might have been kept in check had a full water-supply been available, and the building of the wall rapidly pushed on, to cut off the air before it could reach the inflammable gases, but at the critical moment neither was done. It was not till after the first explosion that the extreme danger of the situation was realized. Had a larger area of the mine been then shut off, it would have required too much time, nor could the men be withdrawn too far, and the fire left unwatched. Hence the manager had no choice but to order the dams to be built at the points which he selected, and it would have appeared a breach of duty to abandon more of the mine than he was compelled to do. Faults once committed, he did his best to atone for them, and paid for errors with his life. It was owing to the good ventilation that there were no further explosions, the fire was localized, and did not spread through the mine, as it might have done, with terrible results. E. M. D.

EXPLOSION OF FIRE-DAMP IN THE WIELICZKA SALT-MINE, AUSTRIA.

Grubengasexplosion im Wieliczkaer Salzbergwerke. ANON. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 335-336.

On May 9th, 1901, a remarkable explosion of fire-damp took place at the Wieliczka salt-mine, killing 1 man and injuring 2 others. It occurred in an excavation 197 feet long, 130 feet wide, and about 6½ feet high, which had been worked for the last sixteen years without a trace of foul air, and in a part of the mine where the salt, called *spiza*-salt, is not known to contain any gas. No such accident had happened in the district since 1797. Had it occurred where *knister*-salt is present in large quantities, it might have been accounted for. This salt, a special feature of the Wieliczka mine, is of a coarse crystalline character, white and transparent, and smells strongly of bitumen. The crystals are full of small bubbles which at a certain pressure are resolved into marsh-gas, hydrogen and brine. The salt dissolves rapidly in water, the bubbles burst, and the gases escape with a loud crackling report, hence the name *knister* or "crackling" salt. This phenomenon could not have caused the present accident, because the explosive gases were generated in the compact *spiza*-salt. The bed of this salt at Wieliczka contains numerous animal and vegetable fossils, and among them lignite, which when decomposed gives off methane (CH_4). Probably, therefore, there was a larger quantity of this lignite in the

neighbourhood than usual, and a cavity had become charged with fire-damp. This being inadvertently opened by the miners, fire-damp had escaped, and when brought in contact with lights was ignited. This theory is confirmed by the fact that when lignite is occasionally met with in the *spiza*-salt beds, there is always a slight escape of gas, which burns with a small blue flame. The explosion was confined to the roof of the excavation, for three cartridges for blasting, which lay on the ground, together with the fuse and a covered hand-lantern, were untouched. E. M. D.

EXPLOSION AT THE KÖNIGIN-LUISE COLLIERY, ZABRZE, UPPER SILESIA.

Die Explosion auf dem Königlichen Steinkohlenbergwerk Königin Luise, zu Zabrze am 2. April 1903. By — DROTSCHMANN. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1903, *vol. li., Abhandlungen, pages* 267-286, *and* 2 *plates.*

Shortly before 1 p.m., on April 2nd, 1903, in the eastern district of the Königin-Luise (Government) colliery, there took place in the 1,115 feet level a coal-dust explosion, which cost the lives of 23 persons, and wrought dire mischief over a radius of 2,000 feet. The disaster has made an especially deep impression, because, owing to the general absence of fire-damp in, and freedom from dust of, the Upper Silesian collieries, the occurrence of a coal-dust explosion had been considered by most of the mining officials as highly improbable. It is true that some insignificant dust-explosions had been recorded previously in that coal-field, but as they had never extended beyond a radius of some 150 or 200 feet, no importance had been attached to them.

The shock of the explosion on April 2nd was felt above bank, and it was followed by thick clouds of smoke rolling out of No. IV. shaft. It is reckoned that 191 men and 9 horses were at work in the 1,115 feet level at the time of the disaster, and many were so fortunate as to escape with very slight injury. At 4 p.m., the pumping-engines on that level were set running again, and the electric light was got once more into working order. Rescue-parties went through the workings, and saved some men who were fast succumbing to the effects of the noxious gases. They found several corpses badly burnt, but curiously enough the 6 horses that were killed by the explosion showed no trace of burns.

A detailed description is given of the havoc wrought in the workings.

From the point of view of the cause of the explosion, it is important to note the occurrence of beads and crusts of coke, also of thick layers of velvety sootlike dust, marking everywhere its course. Such dust had never been observed or even suspected in the pit before: probably much of it, in the course of years, had accumulated behind the timbering. Much, however, must have been evolved by the explosion itself. A review of the available evidence connects the disaster with the firing of two shots, wherein an improper use had been made of coal-dust tamping instead of the prescribed "clay." It has been ascertained that the Upper Silesian pitmen cherish (unfortunately) the belief that coal-dust tamping enhances greatly the effect of a shot. The amount used for the two shots in this case was demonstrably not less than 3 pounds. They were fired one after the other, and it is believed that the explosion followed on the second shot, by which

time an appreciable amount of coal-dust would be whirling in the air, ready to flash into flame. Then, too, there was the dust inevitably produced in boring the shot-holes. The author apparently does not believe that inflammable gases were present in the pit in any appreciable volume. The oxygen of the air was quite sufficient, in combination with the coal-dust, to produce the effects noted. Meanwhile, measures are now being taken to water the workings, and a committee has been formed to consider the best means of combating the dangers of coal-dust in the collieries of Upper Silesia. L. L. B.

INFLUENCE OF PRESSURE ON THE PROPAGATION OF EXPLOSION IN GASES.

Influence de la Pression sur la Propagation de l'Explosion dans les Gaz. By ALEX. DE HEMPTINNE. *Académie Royale de Belgique, Bulletin de la Classe des Sciences*, 1902, *pages* 761-775, *with* 2 *illustrations in the text.*

Temperature and pressure are all-important factors in explosive phenomena. The author describes a series of experiments which he made with gaseous mixtures, using sometimes very low pressures and sometimes very high ones. For igniting the gases he used the spark produced by a Ruhmkorff coil.

From sundry experiments made with mixtures of hydrogen and oxygen, the author is enabled to infer that the electric discharge determines an explosive wave. The violence of the local explosion causes this to take place at lower pressures than are found necessary when ignition is effected by means of an incandescent spiral of platinum. The electric discharge and the formation of a wave being rather capricious phenomena, it follows that the explosion induced by sparking does not always take place at so definitely-fixed a pressure, as when it is started by the incandescent method. It would seem that certain vibrations are especially favourable to the sudden combination of gaseous mixtures.

Phenomena of the same order were observed in the case of mixtures of carbon monoxide and oxygen, methyl-alcohol and oxygen, ethyl-alcohol, ether, benzol, acetylene and carbon disulphide. The results are summarized in the following table:—

Name of Gas.	Minimum Pressure with Electric Discharge.	Pressure with Incandescent Spiral.	Heat of Formation.	Heat of Combustion.	Temperature of Explosion.	Temperature Mean.	Velocity of Explosive Wave.	Velocity of Combustion.
	In Millimetres of Mercury.	In Millimetres of Mercury.	Calories.	Calories.	Degrees Centigrade.	Degrees Centigrade.	Metres per Second.	Centimetres per Second.
Hydrogen ..	35	192	—	58,000	530 to 606	568	2831*	5,780
Carbon monoxide ..	58	145	26,300	68,000	650 to 730	690	1089*	6,700
Methyl-alcohol ..	45	145	48,800	182,200	—	—	2831†	8,450
Ethyl-alcohol ..	40	125	53,000	340,500	—	—	2773†	8,305
Ether	35	125	56,500	659,600	210 to 240	225	2540†	8,942
Benzol..	25	105	−17,100	77,600	—	—	2622†	9,700
Acetylene	15	45	−53,200	310,100	185 to 195	180	2482*	10,070
Carbon bisulphide	12	14	−28,700	265,100	190 to 210	200	1953†	8,270

* Determined by experiment. † Calculated.

From these results the following conclusions are drawn:—

(1) Explosion, in whatever way it may be started, takes place at lower pressures in the case of those gases of which the heat of formation is negative, than in the case of others.

(2) With the exception of hydrogen, there is a kind of parallelism between the minimum pressure at which explosion determined by electric discharge takes place, and the pressure at which it takes placé when determined by the incandescent spiral.

(3) If hydrogen and the substances (the heat of formation of which is negative) be excepted, the minimum pressure, at which a gaseous mixture explodes by sparking, is lower in proportion as the heat of combustion is greater. (The abnormal behaviour of hydrogen under such conditions is doubtless explained by the enormous velocity of its explosive wave.)

(4) There does not seem to be any relation between the temperature of explosion, and the pressure due either to sparking or to the incandescent spiral.

(5) There does not seem either to be any relation between the velocity of combustion, and the limiting pressure at which gases explode by the incandescent method.

On the whole, the more closely the figures in the table are studied, the more it appears that explosion is a highly-complicated phenomenon. One point, however, impresses itself upon us, namely, the undoubted difference in character of an explosion according as it is determined by the electric spark or by the incandescent method. In the first case, the velocity of travel of the molecules seems to play the principal part. In the latter case, the heat of formation, the heat of combustion, and the temperature attained at the moment of combustion, exert a preponderating influence.

Finally, certain experiments at high pressures are described. A mixture of hydrogen and nitrogen was compressed up to 80 atmospheres, yet sparking failed to induce combination to any important extent. A mixture of nitrogen and acetylene was subjected to a pressure of 30 atmospheres, and then on sparking the acetylene was decomposed into hydrogen and carbon, but hydrocyanic acid was not formed (as it is in such mixtures at lower pressures). L. L. B.

THE GIERSBERG LIFE-SAVING APPARATUS.

Der Rettungsapparat Giersberg, Modell 1901. By Dr. Felix Busson. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 350-352, *with* 2 *illustrations in the text.*

The writer describes a trial made at Gelsenkirchen of a new apparatus for saving life in mines. In all appliances hitherto used for this purpose, the supply of oxygen for breathing must be regulated by the worker, but in the Giersberg instrument the compressed oxygen is fed in automatically and continuously, the energy stored up in it being utilized to expel the carbon dioxide generated by the breath, and thus avoid the accumulation of noxious gases. A mask is placed over the head of the worker, fitting closely round the face by means of an indiarubber tube, but leaving the ears exposed; the voice of the man inside can be heard without difficulty. A bag containing the oxygen for breathing is placed under the chin, and into it the carbon dioxide is also breathed. The rest of the apparatus is fixed like a knapsack on the man's back, his arms being free. It consists of two bottles lying horizontally one above the other, containing compressed oxygen, which passes thence into a tube through a valve regulating the amount required for breathing at a time. The tube, to which a pressure-gauge is attached,

is connected to the bag under the chin, and passes on its way the mouth of another tube, containing oxygen which has been already breathed and regenerated. Above the oxygen bottles is the receptacle for the absorption agent, in this case solid alkali, to which the breath is carried off through a tube on the left of the face. Here the carbon dioxide is absorbed, and the oxygen passes on to the main oxygen tube. The pressure of the fresh compressed oxygen acts as an injector, and carries with it this current of regenerated oxygen from the absorption medium. The two pass together to the right-hand side of the bag, where they force out the breath through the left-hand tube, and the cycle recommences. Thus the spent products of the breath are at once carried off, and do not remain to contaminate the fresh oxygen. Instead of a mask, a mouthpiece only may be used. By means of the pressure-gauge the foreman can see that the apparatus is working properly. It contains enough oxygen to last 2 hours, and during that time requires no attention. An injured man can be carried into safety without the rescuer having to renew his supply of oxygen.

The writer considers the apparatus to be the best yet introduced for saving life in mines, but that the foreman, during the work of rescue, would have too much to do to inspect the pressure-gauges. To make it perfect, the wearer ought himself to know when his stock of oxygen is exhausted, and some indication of this is needed. E. M. D.

OXYGEN AS AN ANTIDOTE AGAINST CARBON MONOXIDE.

(1) *Commission du Grisou: Note sur l'Emploi des Inhalations d'Oxygène dans les Cas d'Empoisonnement par l'Oxyde de Carbone.* *By* DR. HENRI LEROUX. *Annales des Mines*, 1901, *series* 9, *vol. xix.*, *pages* 541-543.

(2) *Note sur le Traitement par l'Oxygène à la Pression Atmosphérique de l'Homme empoisonné par l'Oxyde de Carbone.* *By* DR. N. GRÉHANT. *Annales des Mines*, 1901, *series* 9, *vol. xix.*, *pages* 544-546.

After pointing out that the use of oxygen as an antidote in cases of carbon-monoxide poisoning was recommended publicly as far back as 1854 by Messrs. Favre and Giannetti, Dr. Leroux recommends the inhalation of oxygen by means of an apparatus which he says is easy to handle. It consists of a cylindrical indiarubber balloon of a capacity of 1,800 cubic inches (30 litres), communicating by means of indiarubber tubing, provided with a stop-cock, with a glass receiver. The receiver has the form of a wide-bottomed flask, closed by an indiarubber stopper, through which pass two bent glass tubes. One tube takes up the oxygen issuing from the balloon, and dips in the water at the bottom of the flask; the other tube takes in the gas which has been washed in the water at the upper part of the receiver and is continuous with indiarubber-tubing provided with a celluloid or glass mouthpiece. If the patient breathes freely, the mouthpiece is introduced into his mouth; if there is any inclination to lockjaw, then the mouthpiece is thrust into one of the nostrils.

The method of using this, and of initiating aspiratory and respiratory movements, according to the condition of the patient, is described. At least 1,800 cubic inches (30 litres) of oxygen must be poured into the lungs, and Dr. Leroux says that there is no harm in increasing this amount to several thousands of cubic inches (hundred litres), according to circumstances.

Dr. Gréhant's investigations bore on two points:—(1) The different action of mixtures of air and of oxygen with 1 per cent. of carbon monoxide. (2) The length of time required to eliminate carbon monoxide from the blood of an animal, according as the animal is permitted to breathe air or oxygen after being dosed with the poisonous oxide.

A dog, which is made to breathe air containing 1 per cent. of carbon monoxide, dies in the course of 20 minutes, but it may live as long as 2 hours and a quarter, or possibly longer, in a gas consisting of oxygen and 1 per cent. of carbon monoxide. The result of the elimination-experiments showed that oxygen is twelve times as potent as air in clearing the blood of living beings of the poison. L. L. B.

COLLIERY-FIRES CAUSED BY SPONTANEOUS COMBUSTION.

Ueber Oberschlesische Grubenbrände durch Selbstentzündung von Kohle und Massregeln zu ihrer Bekämpfung. *By* — BEYLING. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1902, *vol. l., Abhandlungen, pages* 108-139, *with* 8 *illustrations in the text.*

In the first place, the author gives a sketch of the present state of knowledge as to the general causes of the spontaneous combustion of coal. He then points out how frequent are pit-fires in the Upper Silesian coal-field, especially in certain seams. Those collieries that work the lowest group of Coal-measures, with thin seams, are least often the scene of pit-fires.

As a rule, such fires occur in the goaf, because it is there that the preliminary conditions for spontaneous combustion are most favourable. Moreover, in the case of seams so thick as the main seams of the Upper Silesian coal-field it is impossible to work the coal clean away—a greater or less quantity has always to be left in the goaf; and though the last-named may be carefully dammed off, the ingress of atmospheric air cannot be altogether prevented. On the contrary, as section after section of the workings proceeds, and the goaf is inevitably broken into, fresh air-currents have a constant opportunity of access. Then, too, it is the custom in Upper Silesia, to break down a worked-out place, and thereby the danger is incurred of placing these vast hollow spaces in communication with the surface by means of the resulting rents and fissures.

In open workings, on the other hand, the conditions which favour the spontaneous combustion of coal are generally absent—heaps of the mineral are seldom allowed to lie about there for any length of time. In those cases where workings are heavily timbered, hollows in the roof must be sedulously packed, if fire is to be avoided.

Concerning the interval of time which usually elapses between the commencement of the winning of a seam and the outburst of fire in the goaf, it has been found in Upper Silesia to average between 2 and 3 years. It is impossible, however, in this matter to lay down any hard-and-fast rule: the interval has been known to vary from 9 months to 5 years, and where the regular stratification of the seams is disturbed the time is merely a question of a few weeks.

The author enumerates and describes the preliminary conditions without which a pit-fire (from spontaneous combustion) can hardly arise. These depend on (1) the character of the coal, whether pyritous or not, etc.; (2) the lie of the seams, their thickness, etc., and the character of the roof; (3) the method of working; and (4) the mode of ventilation, though whether this be insufflating or not is of no consequence as regards pit-fires.

He then proceeds to consider the manner in which such conflagrations usually start, and points out that in most Upper Silesian collieries, the outburst of gases of combustion from the goaf has been found to coincide with a sudden fall of the barometer. The actual bursting into flame of the coal is of far less frequent occurrence than the evolution of these gases. Fire in the goaf always tends to travel towards the point from which oxygenated air-currents are coming to feed it.

Some attention is then given to the duration in time and the propagation in space of pit-fires, after which the measures by which such fires are to be combated are considered. These measures are first of all preventive rather than remedial, and they consist in avoiding premature forewinning; in making the drifts (at great cost) of smaller dimensions than formerly; in constructing small, comparatively isolated working-districts; in careful and heavy timbering of the bord-and-pillar sections; in leaving the coal untouched at fissures; in securely damming-off worked-out places, etc. When it is a case of stopping the further spread of pit-fires, the following additional precautions suggest themselves: the immediate erection of dams at important points in the airways, etc.; artificial ventilation by means of modern ventilators; independent ventilation of the separate districts, etc.

It is desirable that such measures should be employed in all fiery mines, but unfavourable local conditions may, of course, enhance the difficulty of applying them. So far as Upper Silesia is concerned, the author points out that there remains one safe method of working when all other means have failed: that is, as working proceeds, to pack immediately the empty spaces with sand. For instance, at the Brandenburg colliery, where the Pochhammer seam is worked, some 23 feet thick, sand-packing is used: the sand is dredged up somewhere in the neighbourhood, and is sent down the pit at considerable expense. In the Myslowitz colliery, the sand is washed down by water through a system of pipes into the worked-out places. The avoidance of the waste of coal which pit-fires occasion amply compensates the cost; not to speak of the far more important considerations of the safety of the workpeople and the general improvement in their health.

L. L. B.

FIRE AT THE "LUDWIGS-GLÜCK I." COLLIERY, UPPER SILESIA.

Der Brand auf dem Steinkohlenbergwerke "Ludwigs-Glück I" in Oberschlesien und seine Wältigung. ANON. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1903, *vol. li., Abhandlungen, pages* 149-159, *with* 4 *figures in the text and* 7 *plates.*

This fire, which caused damage to the estimated amount of £200,000, started on Sunday, November 19th, 1899, in a shaft by which the middle (or 590 feet) level communicates, apart from the main shaft, with the bottom (or 713 feet) level.

In ventilating the pit, care had been taken to split the air-currents as much as possible, because it was known that at many points the goaf was smouldering. The actual causes of the fire about to be described is unknown: although some smithy-work had been done in the neighbourhood of the shaft up to about 10 a.m. on the day of the disaster, the available evidence tends to disprove any causal connexion between it and the outbreak of fire.

The flames spread with such rapidity, from the moment that the alarm was raised, at 5·15 p.m., that the whole shaft was involved before it was possible to bring the extinguishing apparatus to bear upon it with effect,

and efforts were thereupon successfully directed to walling off the downcast shaft from the seat of fire. The winding-shaft, however, at the upper (or 282 feet) level was invaded by smoke and gases of combustion; and a miner, who attempted to seal up hermetically the aperture by which these made their way into the winding-shaft at that level, was carried to bank unconscious. A rescue-party, who attempted to complete his work, unfortunately took naked lights down with them, and an explosion occurred just as they were about to step out of the cage. The cage was drawn up at once, and the members of the rescue-party were found to be all suffering from more or less serious burns. The immediate result of the explosion was a reversal of the ventilation, and the renewed incursion of smoke and gases of combustion in both the downcast and upcast shafts. It was known that 11 miners were in the pit, but all hope of saving them (if still alive, which appeared impossible) was abandoned, and both shafts were now sealed down. In the course of this operation, a second explosion took place, as the gases of combustion streaming up from the Guido shaft caught fire at a lantern carried by a workman. The buildings around the pit-head were immediately wrapped in flames, and the most strenuous exertions of the fire-brigade were needed to save the boiler-house, the coal-screening apparatus, etc.

Although the fire was got under after several hours' work, there remained the problem of avoiding the drowning-out of the pit. It was estimated that water would begin to rise in the workings 36 hours after the underground pumping-engine had stopped, and to check this it would be necessary to make the winding-shaft accessible down to the bottom-level. After various searching tests had been applied, with the view of ascertaining the conditions and composition of the atmosphere in the pit, that shaft was reopened on December 30th, and the upper level was reached on the same day, the ventilator there being found uninjured, despite an explosion having taken place in its immediate neighbourhood. A search-party (provided with pneumatophores, although measures were taken to ventilate the pit provisionally) found a day or two later the bodies of the 11 missing men: some of them appeared to have been asleep when death overtook them.

In order to drain the pit eleven pumps altogether were erected: with the first two, pumping was begun on February 4th, 1900, but the work of drainage was only completed in September 1901. Many unexpected difficulties had been met with, and moreover the necessity of simultaneously contending with the fire still burning in some of the underground workings, had constituted a formidable obstacle.

It may be mentioned here that two electrically-driven pumps (the others were driven by steam) proved especially serviceable, and were found very seldom to need repairs of any kind. The underground pumping-engine was found to have suffered so little damage that it was set at work again a fortnight after the deep-level had been made accessible.

A detailed description is given of the gradual methodical way in which the fire was fought out of existence inch by inch, month after month; but, even when this had been accomplished and the pit had been drained, much remained to be done. No less than 40,000 feet of haulage-way, etc., had to be cleared of refuse, 150 masonry-dams to be rebuilt, and about 20,000 feet of pit-props to be replaced. It was not until October 1902 that the colliery reached its former output, and the management are still burdened with expenditure which can be traced back to that unlucky Sunday afternoon in the late autumn of 1899. L. L. B.

FIRE IN A COLLIERY AT WALDENBURG, SILESIA.

Der Grubenbrand im Hermannschachtfelde der Cons. Fürstensteiner Gruben bei Waldenburg i. Schl. am 24. Mai 1901. ANON. [OFFICIAL]. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1902, *vol. l., Abhandlungen, pages* 92-97, *and* 1 *plate.*

The Consolidated Fürstenstein collieries at Waldenburg are classed among fiery mines, but it so happens that No. 10 district of the Hermann pit, in which the fire herein described occurred, is free from fire-damp. The only lights used are safety-lamps of the Wolf pattern. The ventilating-shaft, in the north-eastern angle of the property, goes down 275 feet to No. 9 seam (the fourth level), and besides serving the purposes of ventilation was chiefly used by the miners for travelling to and from bank in wooden cages. Only a small number (those who were working at the middle level) went up and down by the Hermann shaft. On May 24th, 1901, shortly after 3 p.m., the timber-shed built over the ventilating-shaft, in some unexplained way, burst into a blaze. It was in a small fir-plantation on the Butterberg, many hundred yards distant from dwellings or workshops, and somewhat over 100 yards south of the old high road from Waldenburg to Altwasser. The building of a fire-proof shed had been insisted on by the mining authorities, but as so much other constructional work was going on at the colliery, and the chances of fire appeared remote, the rebuilding had been by permission postponed and was to be carried out in the ensuing autumn. All those who went down the pit for the afternoon shift between 2 and 2·30 p.m. had locked safety-lamps; there is evidence to prove that no one was smoking among the late comers, and the fire can only be attributed to incendiarism. All efforts to trace the criminal have proved so far unavailing.

The conflagration soon spread to the timbering of the shaft, and this being a downcast and the ventilators being at work, the flames and smoke were drawn down into the pit. Water was not at hand, and a vain attempt was made to stifle the flames by shovelling earth into the shaft. The alarm was spread through the pit, and by stopping the ventilators the burning shaft was turned into an upcast: it was by that time past 4 o'clock, and the suffocating gases had now spread through a considerable portion of the workings. In a futile endeavour to escape, 17 men met with their death, and 1 man was killed at the working-face. Up till about 5 p.m., 22 men came, one by one, safely to bank. Then the rescue-parties commenced their heroic work, and laboured (unfortunately with the loss of 2 more lives) until 11 p.m., when it was found impossible to advance farther into the workings. One man found completely unconscious was restored to life by insufflation of oxygen from the oxygen-holders which the rescuers brought with them.

Meanwhile, a long procession of water-carts was brought up to the pit-mouth, and the hose was vigorously played on to the burning shaft. About 6 a.m., on May 25th, it became possible to get into the shaft, and then to attack the burning No. 2 seam, which had caught fire from the blazing timbering at the uppermost level (30 feet or so below bank). The men, who were chosen to accomplish this task, were sent down in a cradle suspended by a rope, and were provided with smoke-proof masks. About noon, their efforts were so far successful that it was possible to restart the ventilators, and temporarily to retimber the burnt-out portion of the shaft. The rescue-parties then entered the pit by that shaft as well as by the

Hermann shaft, and penetrating into workings which they had hitherto been unable to approach found about 9 p.m. a hewer still alive, although he had spent about 30 hours, mostly in a comatose condition, in an atmosphere of poisonous gases. He was brought safely to bank.

The circumstance that the rescue-parties, during the actual progress of the conflagration, had been able to travel a comparatively long distance through the workings, is attributable to their having taken with them the oxygen-holders from the pneumatophores. It was not considered desirable to equip the rescuers with the pneumatophores themselves, on account of the very low roofs under which they needs must pass, and such like difficulties.

L. L. B.

FIRE AT POCAHONTAS MINES, VIRGINIA.

Disaster at Pocahontas Mines. *By* CHAS. S. THORNE. *Mines and Minerals*, 1902, *vol. xxii., page* 262.

The Baby and West mines, at Pocahontas, form part of a group of five mines, the other three being entirely separate, but the Baby and West mines are connected underground.

On November 14th, 1901, at 4 a.m., a fire was discovered in the Baby mine exhaust-fan. Further examination disclosed fires at four different points near the main entry and the fan-entry of the Baby mine, all fairly well under way, separate and distinct from each other. The first of these was found about 700 feet from the Baby mine pit-mouth on No. 1 entry on the straight mine-track. At 5 a.m., a fall of roof caused a disturbance of the gases gathered in the rear of the fire, resulting in a slight explosion. Without injuring any of the exploring party who were within 50 feet, the explosion blew out some brattices, permitting the smoke and gases to pass through the old workings of the Baby mine into the West mine, and, before warning could be sent, 9 men were suffocated in the West mine at a distance of 1 mile from the site of the fire.

When it was found that the smoke was drifting into the West mine, the fan at the Baby mine was started, in order to draw the smoke from the West mine over the fire in the Baby mine and thus give fresh air to the West mine. The result was, that the gases previously generated by the fire and drifted with the smoke, were carried back mixed with fresh air over the fire, and a second explosion occurred between 9 and 10 a.m. No one, however, was seriously injured thereby. In fact, no fatalities occurred in the Baby mine or within 3,000 feet of the site of the fires.

The bodies of the 9 men suffocated were recovered a day or two later, but a distressing occurrence was to follow. It was found that the West mine could not be worked while the Baby mine-fire was in progress, and after putting up some brattices partly separating the two mines, the superintendent, Mr. W. O'Malley, the engineer, Mr. F. Bell, the general manager, Mr. Joseph Cardwell, Mr. A. S. Hurst, the mine-inspector, Mr. W. Preece, and the coal-inspectors, Messrs. W. Oldham, M. St. Clair and R. St. Clair, making a party of eight, went into the West mine at noon on November 22, to make investigation of the conditions. At the time the party entered, the West mine fan had been running for 8 hours at 30 revolutions per minute. The party left directions as to what doors were to be left open. This gave them good air to a point about 1,500 feet in, but they went beyond this point, and it transpired that the brattices between the mines did not completely cut off the gas, which thus drifted up into

the higher workings of the West mine. The party passing beyond the shorter circuit of ventilation entered these higher workings and were suffocated. This gas was white damp or carbon monoxide, and had the distinct odour which accompanies coal-distillation. After more brattices had been put in, the 8 bodies were recovered on November 24 at a distance of about 2 miles in the West mine, all the party having died from suffocation.

The system of fighting these fires had been to supply them with water through pipes extended into the workings, and after these pipes were extended, to seal off the old entries with curved brick-dams. The pipes extending through these dams have been used for flooding the district in which the fire is located. In this manner, the fire is being gradually extinguished. The West mine, through which gas and smoke naturally drift on account of the higher elevation, is also being cut off from the old section of the Baby mine by brick brattices and dams, in place of the temporary wooden brattices. X. Y. Z.

EXPLOSION OF A PIT-HEAP IN GERMANY.

Explosion auf einer Bergehalde. By — POMMER. *Zeitschrift für Praktische Geologie*, 1902, *vol. x., page* 381.

At about 2·30 p.m. on Sunday, May 25th, 1902, an explosion took place on the heapstead of the Kaiser-Friedrich pit at Barop. Great masses of the pit-waste were hurtled through the air into the neighbouring gardens, and these were at the same time flooded by the water escaping from the spraying-tanks at the heapstead.

As this heapstead, the internal portion of which was on fire, was being sprayed with water pumped up for that purpose (at the rate of 52 to 70 cubic feet a minute), it may be inferred that the water coming into sudden contact with a focus of combustion had flashed into steam, and thereupon torn up the pit-heap with explosive violence. Onlookers said that the explosion was accompanied by a report like a clap of thunder, while a great column of flame shot up into the air.

The mass of material thus "moved" is estimated at 14,000 cubic feet, and many of the fragments strewn over the neighbourhood weighed as much as 1 cwt. Most of the pit-waste so found is baked red. A steep, crater-like depression was formed in the heap, 13 feet in depth.

L. L. B.

INRUSH OF WATER AT THE KOMMERN COLLIERY, BOHEMIA.

Der Wassereinbruch am Jupiterschachte in Kommern (Böhmen) am 14. Jänner 1902. By FRIEDRICH OKORN. *Berg- und Hüttenmännisches Jahrbuch der k. k. Bergakademien zu Leoben und Přibram und der königlich ungarischen Bergakademie zu Schemnitz*, 1903, *vol. li., pages* 63-133, *with* 3 *figures in the text and* 4 *plates.*

On January 14th, 1902, about 11·45 a.m., an inrush of water took place in the Jupiter pit of the North Bohemian Colliery Company at Kommern, whereby the manager, three other officials, and 39 pitmen lost their lives; 80 others found safety in flight, most getting out by the Jupiter shaft, and a few by the neighbouring Guido shaft.

The invading waters came from above. They had accumulated in fissures and depressions over the roof of the workings; and, on the breakdown of a certain area in the eastern district of the colliery, the waters poured in, sweeping away dams and pillars, and engulfing the unfortunate miners, warned too late by the alarm-signals. The manager himself, apprised by the alarm-signal in his office that something was wrong, hastened down the pit to meet the fleeing crowd, and was among those overtaken by the flood. The point where the water burst in is 2,160 feet north-east of the Jupiter shaft, and 2,300 feet south-east of the above-mentioned exit into the Guido pit.

The Biela river, which flows through the coal-field with many windings from west to east, overflows its banks at least once a year, and vast areas lie under water for weeks together: at such times, the drainage or regulation of the accumulations of water which overlie the colliery-workings is simply impracticable. Public works on a vast scale are needed to regulate the river and deepen its bed, and the necessity for these has long been recognized.

Already in May, 1898, an inrush of water had taken place in the Jupiter pit, whereby 2 persons lost their lives; and, in consequence, very strict rules had been drawn up by the mining authorities in regard to the further working of that pit: these are recapitulated in detail by the author. The government inspectors of mines watched the enforcement of the new rules, and their report of August 10th, 1900, embodied no complaint of laxity or neglect. Towards the end of March 1901, the management had to report an inflow of water of comparative unimportance in the eastern district, and as a consequence certain portions of the workings were securely dammed off. The Government inspectors of mines again reported favourably as to the state of the pit on September 27th, 1901; the workings were kept perfectly dry by electrically-driven pumps stationed above bank.

The testimony of the survivors from the disaster of January, 1902, is given in great detail, and makes interesting reading. One gathers, on the whole, that such confidence was felt in the precautionary measures which had been taken against the inrush of water, that in many cases the true nature of the catastrophe was not realized at first. Yet for several days previously, ominous cracks had been heard and other signs had been noted of a possible breakdown of the workings at the very point where the inrush took place, but the dam walling off the goaf had been strengthened on January 8th (6 days before the disaster), and thus no great importance appears to have been assigned to the above-mentioned warnings. From January 2nd onwards, heavy rains had fallen, the Biela river was in flood, and the surrounding country must have presented the appearance of a great lake.

The water in the drowned pit subsided very slowly and irregularly, but by dint of immense exertions and the addition of four electrically-driven pumps to the two already at work, the pit was at last made accessible on April 14th, 1902. Working has not, however, been resumed in it so far.

The author sums up carefully the available evidence as to the circumstances of the disaster and the conditions of the pit, and concludes that no blame is justly attributable to the management. L. L. B.

UNDERGROUND ELECTRIC PUMPING-ENGINE AT COURRIÈRES COLLIERIES.

Note sur la Pompe électrique de la Fosse No. 9 des Mines de Courrières. By — BAR. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 68-71.

The electric pumping-plant is calculated to raise 44,000 gallons (200 cubic metres) of water per hour from a depth of 820 feet (250 metres). The plant consists, on the surface, of a twin Corliss engine, coupled directly to a flywheel alternator, giving a triphase current of 2,000 volts; and underground, of an asynchronous motor receiving the current, and driving by belts a three-throw pump at the 600 feet (184 metres) level, where the water collects in a lodge of 110,000 gallons (500 cubic metres) capacity.

The cost of the plant, not including the surface or underground engine-room, amounted to £6,400 (160,000 francs); and at first the specified volume of water was raised. With a view, however, to avoid the shocks due to fast running, the three suction-valves and three delivery-valves are each constituted by four clacks, with superposed seats of decreasing diameter; and this arrangement has not continued to give the desired results, for the following reasons:—(1) The clack consists of a gun-metal disc and a cast-iron guide ring, connected by rivets, with an intervening leather washer for increasing the tightness; and this washer, more or less supple, between two parts that require to be rigidly connected, causes their dislocation and leads to fracture. (2) The cast-iron seats afford a large total sectional area; but each one is narrow, so that the water is wire-drawn, exerts great friction on the sides, eats them away and soon renders the valves unserviceable. J. W. P.

PUMPING ON THE KASELOWSKY SYSTEM.

Visite des nouvelles Installations de la Compagnie des Mines de Montrambert et de la Béraudière : Puits Ferrouillat. ANON. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 155-156.

This pump, which delivers with remarkable regularity, is capable of raising 39,600 gallons (180 cubic metres) of water per hour from the depth of 2,132 feet (650 metres); but at present the depth is only 1,510 feet (460 metres). The force-pump on the surface, with pistons, 5·67 inches (144 millimetres) in diameter, makes 20 double strokes per minute, and is driven by a compound steam-engine with cylinders, 28½ inches (725 millimetres) and 47·24 inches (1,200 millimetres) in diameter respectively and a stroke of 47·24 inches (1,200 millimetres). The boiler-pressure is 114 pounds per square inch (8 kilogrammes per square centimetre). The pipe leading the motor-water down the shaft is made of drawn steel, without weld, 2·76 inches (70 millimetres) in inside diameter; and the return-water pipe is of lap-welded wrought-iron, 8·86 inches (225 millimetres) in inside diameter at the bottom, increasing to 9·06 inches (230 millimetres) above.

The underground pump has four plungers, coupled two and two, 10·24 inches (260 millimetres) in diameter and a stroke of 31·50 inches (800 millimetres). J. W. P.

COAL-WASHING.

Considérations sur le Lavage des Charbons: Contrôle du Fonctionnement des Appareils par l'Étude graphique de la Nature et de la Composition des Mélanges traités. By PIERRE CHARVET. *Bulletin de la Société de l'Industrie Minérale*, 1903, *series* 4, *vol. ii.*, *pages* 535-572, *with* 11 *figures in the text.*

As collieries are exhausted, it becomes necessary to work seams of inferior value in regard to the ash-content or the proportion of small coal; and it is almost a general rule that coal becomes less and less bituminous, and therefore less easily utilizable, as the depth increases, so that the importance of washing is evident. In this problem, the following are the three main points to be attained:—(1) To obtain saleable products as pure as the consumer's interest requires; (2) to reduce the waste, or loss, to a minimum, that is, to obtain the greatest possible yield; and (3) to keep the cost of labour as low as possible.

The striving after a reduction of the cost of labour has brought into use plant of large capacity, in which all the manipulations are effected mechanically, so that it is not unusual to see only one man in charge of various appliances that wash 350 or even 400 tons of coal in a single shift.

However capable may be the workman, he is not infallible; and the least mistake is of great importance, so that the necessity arises for keeping a permanent check upon the quality and quantity of the products. The quantitative yield may be calculated with sufficient approximation; but it is far from being the case as regards the quality, that is, the ash-content. There is, however, great difficulty in taking from a stock of small coal a series of samples, whose mean ash-content approximately represents the bulk; and when the samples are taken, and analysed by workmen or employees who may find it more convenient, sometimes even less compromising, to furnish incorrect rather than true results, the matter becomes difficult.

Laboratory-tests are therefore only conclusive when a sure and rapid check can be kept upon them; but, supposing the check on the laboratory to be as perfect as may be desired, if the tests indicate the results, they do not show the value of the results. A standard of comparison is wanted for giving information as to the mixture treated, and any advantage that there may be in modifying the method employed. Such a guide can only be afforded by washing-tests on a far larger scale; but these are made with difficulty, so that it would seem very useful to have a laboratory-apparatus and a method capable of taking their place, while at the same time showing that the supervision of the washing-floor is sufficient. The empirical tracing of graphic curves appeared to the author convenient for attaining these two objects; and he describes the method of obtaining them and of analysing, interpreting and representing geometrically certain results which they afford.

From the aspect of the empirical curves obtained it is possible, by comparison with corresponding theoretical curves, to deduce such hypothesis as may appear well-founded, concerning the nature of the mixture and the intimate constitution of the grains composing it. It follows that, for a given state of division, we may, by comparing one with the other and with the theoretical curves various curves afforded by different coals, obtain valuable indications as to the nature of the seam and the purity of the still unwrought coal. We can in this manner clearly ascertain whether the alteration of the coal that requires washing is natural and inevitable, or

whether on the contrary, as is too often the case, this alteration is artificial and caused by the method of working, defective in this respect, or from want of care in the actual getting.

By making a series of tests on one and the same quality of coal, while varying within predetermined limits the dimensions of the grains, a series of curves will be obtained which, compared with those corresponding with a uniform dimension of the grains, will show up to what point it may be advisable to push the previous volumetric classification, in order to give the density sufficient preponderance.

Normally, all coals to be washed, from the different seams or districts of a colliery, go to form an average mixture, which is not very subject to sudden variations, but nevertheless changes insensibly and continually. On the other hand, contracts and conditions of sale become modified, so that it is necessary to make complete tests from time to time. In this case also a check by the curves is indicated, and shows whether the work of the washing-floor is commensurate with that of the small washery, and consequently whether the classification obtained by the full-sized plant comes sufficiently near to the best, or ideal, classification. Lastly, in the case, which frequently occurs, where the washing-plant comprises different appliances, comparative trials may show conclusively which kind of washers are best suited for this or that kind of coal. J. W. P.

THE WILFLEY TABLE: EXPERIMENTAL TESTS.

Lake Superior Developments. *By* HORACE J. STEVENS. *Mines and Minerals*, 1901, *vol. xxii., page* 71.

One of the most exhaustive tests has been completed at the Wolverine mill. The Wilfley table was run side by side with an Evans slime-table. The round table in 3½ days saved 2,255 pounds of straight slime from the boxes, without tossing, the slimes assaying 3·4 per cent. of copper. After tossing, the weight was only 90 pounds, carrying 16·45 per cent. of copper. The tailings from the round table assayed 0·49 per cent. of copper. These tailings were run over a Wilfley table immediately after leaving the round table, and the latter saved 600 pounds of slimes assaying 4·18 per cent. of copper. The tailings from the Wilfley table in this case assayed 42 per cent.

Side by side with the round table, another Wilfley table was run for the same time on slimes identical in nature. The Wilfley table saved only 735 pounds of slimes before tossing, but the percentage of copper therein was 13·98, and the weight, after tossing, was 390 pounds, averaging 18·23 per cent. of copper. Fed alike, in this competition, the round table saved three times the weight of the Wilfley table in slimes, but after tossing the weight of the round-table slimes shrunk to 4 per cent., while the much smaller product of the Wilfley table remained at 53 per cent. of the original weight. The net saving, on identical matter, was 14·8 pounds of refined copper by the round table, and 71·09 pounds by the Wilfley table. To complete the test, the tailings from the second Wilfley table were run over an Evans table. The assayed percentage of copper in the tailings of the Wilfley table was 0·23 per cent. From these tailings, the round table in the train of the Wilfley table secured 1,040 pounds of slimes assaying 2·51 per cent., making 22·36 pounds of refined copper, and the tailings assayed 0·18 per cent. The round table uses about 100 gallons of water per minute, while the Wilfley table averages only 6 gallons. X.Y.Z.

A MODEL TRAMWAY AND SAMPLER.

A Model Tramway and Sampler. By JAMES H. STEELE. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 596-597, *with* 3 *illustrations in the text.*

Ore-Sampler.—On June 1, 1901, the Silver King Mining Company of Park City, Utah, put its new 250 tons automatic sampler and aerial wire-rope tramway into commission. The working of both has been practically perfect since the first run. The sampler is entirely automatic in operation. It is regularly run by 3 men, the foreman, helper and engineer. In the second week of its run, a lot of 175 tons was put through in 5 hours. To show the automatic properties and general efficiency, it is stated that the constructing engineer assisted by the writer put through 165 tons of crude ore in 3½ hours, from the time of opening the feed-gate till the duplicate samples were in the assay-office. This run was made under every-day working conditions, except that the entire regular crew, including the engineer, was laid off.

The sampler-building is 71 feet by 52 feet (exclusive of the engine and boiler-rooms) and is 95 feet high, having 5 floors. The receiving-bins are four in number, resting on masonry pillars, and have a capacity of 250 tons each. The four shipping bins, in front of and below them, are similar. A Robins belt-conveyor, 24 inches wide, carries the ores from three of the bins to the initial crusher, the gate of the fourth bin being placed directly over the crusher. The conveyor delivers the ore to a Comet gyratory crusher with a capacity of 50 tons per hour. There are 5 elevators in the sampler, side by side, with their boots all on the same floor.

No. 1 elevator handles the entire product from the crusher, and has a belt 2 inches wide. From the head of this elevator the ore passes through a Vezin sampler where 20 per cent. is cut out for a sample. The 80 per cent. of " reject " falls to the boot of No. 3 elevator, which handles the reject from all the samplers, using a belt 12 inches wide. The ore passes from the elevator to a hopper provided with a revolving spout, by which the ore may be directed to any one of the four shipping-bins. The 20 per cent. sample passes through a pair of high-speed rolls, and is crushed to pass through a ¾ inch screen. No. 2 elevator raises the sample to No. 2 sampler, where another 20 per cent. cut is made. The reject follows the same course as before, the sample going to a pair of rolls which crush to ⅜ inch. This product is elevated and sampled as before, and the remainder reduced to 8 mesh. It is now passed through a twin sampler which cuts out duplicate samples of about 300 pounds each, and these fall into small bins above the sample-grinder on the roll-floor. The contents of these bins are in turn passed several times through the sample-grinder, where they are reduced to 40 mesh and to about 10 pounds in weight. These final samples, after being ground to pass through 200 meshes and steam-dried, are ready for the assayer.

Aerial Tramway.—In the past, the ore from the Silver-King mine has been taken by wagon to the McIntosh sampler at the lower end of Park City. The road was costly to keep in repair and difficult to keep open in winter, and a rope-tram seemed the simplest and best means of obviating the difficulty, whilst the large output of the mine warranted the construction of a sampler in connection.

The tramway is of the Finlayson type, and lies along the ridge of hills to the north of the mine and down a sharp incline to the lower end of Park City. It is supported on steel towers, varying in height from 16 to 65

feet. The greatest distance between supports is 200 feet. The line is over 7,000 feet long, and has a fall of 1,000 feet. There are 80 buckets spaced 175 feet apart on the line, each having a capacity of 500 pounds of ore and 325 pounds of coal. The present speed is 150 feet per minute, but the speed of the line or the number of buckets, or both, may be increased at any time as the mine-output may require. The ropes are of crucible-steel, the breaking strain being 100 tons per square inch. The traction-rope is ¾ inch in diameter; the standing rope on the down side is 1⅛ inches, and that on the up side 1 inch, in diameter. The idler-pulleys on the towers are lubricated, and the standing ropes are tarred, automatically. All the mine-and-mill supplies are carried by the tram. The weight of the descending ore develops power to run the tram and three supply-elevators at the lower terminal. The tramway enters the lower terminal station at Park City at a height of 85 feet above the ground. The automatic unloading device and the coal-and-supply loading apparatus are located on this floor. The ore is dumped into a hopper placed at the common corner of the four bins with which this station is supplied, and a revolving spout is used to direct the ore into any one of these. X. Y. Z.

CEMENTING-MATERIALS FOR BRIQUETTE-FUEL.

Bindemittel für Brennstoff briketts. *By* DR. — STEGER. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1902, *vol. l., Abhandlungen, pages* 311-320, *with* 6 *figures in the text.*

The author remarks that, in preparing briquettes of peat and brown coal, no substance for binding the material together is needed. The application of sufficiently high mechanical pressure and the maintenance of a certain degree of humidity in the peat or brown coal are the sole indispensable conditions.

It is true that, in some brown coals, the contained bitumen serves to bind them together into briquettes, but the capabilities of the bitumen in this respect do not depend so much on the quantity of it that is present as on its chemical composition. Thus some brown coals poor in bitumen yield better compacted briquettes than others which are richer in bitumen.

In ordinary coal, the contained bitumen begins only to soften at temperatures above 392° Fahr., and even then the mechanical pressure necessary to compact the coal into briquettes just as it is, would be so enormous that the process would not pay.

The cementing-materials that have been longest in use in the manufacture of briquette-fuel are pitch, tar, and the allied substances. Briquettes prepared with pitch retain unimpaired for a considerable time, for many years indeed, their calorific properties. At the Imperial Dockyard at Wilhelmshafen it has been experimentally ascertained that such briquettes make less smoke in burning than the coal from which they are prepared. This may arise from the circumstance that their structure is evenly compact throughout.

Tar is a less satisfactory material for the purpose, even if saponified with alkalies by the Reinhold-Martin process.

In selecting other cementing-materials it is well to choose organic substances, as they help the combustion; while inorganic substances are in themselves incombustible, increase the waste in the form of ash, and take off

with them some of the heat. Many British patents have been taken out for the use of asphalt in this connection, but it is on the whole too costly, and can be better utilized in paving, etc.

A British patent of 1886 contemplated the application of petroleum to briquette-making, but other far from satisfactory substances were to be used with it, such as sulphuric acid and lime. Recently, a process has been patented in Galicia by Dr. Bernhard Diamand, embodying the utilization of petroleum-refuse in briquette-making, but for reasons which the author assigns, the process does not seem likely to meet with unmixed or universal approval.

Various other processes are described, and dismissed with faint praise, such as those in which the Jurassic *Posidonia* oil-shales of Reutlingen, after crushing and distillation, are used as the binding-material; or those in which the application of soot, starch, Carragheen moss, molasses, and cellulose finds a place. On the other hand, the utilization of sulphite-cellulose residues, a very troublesome variety of factory-waste, appears to the author fairly promising. Mr. Fiedler, Munich, proposes in this connection the use of the following mixture for briquette-fuel: 87 per cent. of coal-duff, 10 per cent. of sulphite-cellulose residues, 2 per cent. of blood, and 1 per cent. of lime. Blood is introduced here, because of its remarkable agglutinating properties. Derivatives of resin, albuminous substances, sawdust (from resinous timber) and even fæcal matter, have all been the subject of industrial experiment, and in some cases of patents.

The author then passes in review the various inorganic substances that have been proposed or used for cementing coal-dust into briquettes. In many cases these substances are intended to play a twofold part—that is, to accelerate combustion as well as to hold the stuff together; as, for example, the process wherein powdered clay, alum, and Chile saltpetre are mixed with the coal. Messrs. Dörr and Oidtmann propose to make use of the carbonaceous shales in pit-heaps by grinding them very fine, and then making them into briquettes with an admixture (if needful) of coal-dust, peat or sawdust, and a suitable binding-material. L. L. B.

SCHNABLEGGER COKING PROCESS FOR UTILIZING SAWDUST, PEAT, LIGNITE, ETC.

Schnablegger's Verfahren, Sägespäne, Torf, Lignit und Braunkohle zu vercoken. By F. Toldt. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1902, *vol. l., pages* 195-197, *with* 6 *illustrations in the text.*

The author has examined samples of coked sawdust, peat, lignite, etc., prepared by the Schnablegger process (the particulars of which are not divulged by the inventor), and finds that fusion has occurred in the oven, the coke of peat and lignite exhibiting a columnar structure and cauliflower surface. Certain adjuncts, which are said to be readily obtainable, are added to the material before the actual operation of coking is performed. The more finely divided the material and the lower the percentage of ash-constituents the better, so that sawdust forms the best material for producing a cheap coke by this process. The product appears suitable for all metallurgical uses, including blast-furnaces, and the process may therefore find profitable application in places where iron-smelters are short of fuel, although in the immediate vicinity of supplies of lignite. C. S.

COKE FROM NON-COKING COAL.

Note sur la Fabrication du Coke par le Procédé Hennebutte. By MARC WAROLUS. *Publications de la Société des Ingénieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut*, 1902, *series* 3, *vol. xii., pages* 40-53.

Most coals when stacked deteriorate, and sometimes heat so as to ignite. Mr. Fayol found that this alteration is due to the oxidation of the coal, and not of the pyrites, as was generally supposed. By scientifically interpreting the results arrived at by Mr. Mahler, Mr. Hennebutte has succeeded in constituting the substance that is wanting in some coals for producing coke. Leaving out of the question anthracites and non-bituminous coals, it may be said that the effect of exposing coal to the air is to increase its weight, the action of heat acting as adjuvant within certain limits, while the increase of weight in bituminous coals sometimes attains 10 per cent. in a week. Mr. Mahler found that Commentry coal containing:—Carbon, 85·664 per cent.; hydrogen, 5·604 per cent.; and oxygen with nitrogen, 8·732 per cent., subjected to a heat of 248° Fahr. (120° Cent.) for a week in a drying stove, then contained:—Carbon, 72·652 per cent.; hydrogen, 3·347 per cent.; and oxygen with nitrogen, 23·911 per cent., while the calorific power had diminished by 20 per cent.

Chemists have long known that peats and lignites contain a special hydrocarbon only met with in coal in its normal state, and which on oxidizing gives rise to ulmic acid. Oxidated coals, those cropping out at the surface, coal-dust, etc., take on again to a certain extent the properties presented in past geological periods by the decomposing plants which formed them. By oxidation also coal loses its caking power; and by heating a coal from the Lens colliery to 212° Fahr. (100° Cent.) for a year Mr. Campredon reduced its caking capacity from 13 to 0. Accordingly the action of oxygen, by forming ulmic acid, at length entirely destroys the cementing substance of the coal.

Mr. Mahler concluded that the substance indispensable for the agglomeration of coke must be sought among the hydrocarbons susceptible of transformation into ulmic acid on contact with oxygen; and Mr. Hennebutte has succeeded in finding a hydrocarbon that combines the necessary properties. His investigations have shown that the caking power of a coal to be coked is a function of the quantity of nascent carbon or cementation-graphite produced by the dissociation of the hydrocarbons during its carbonization. The coals capable of yielding blast-furnace coke are those containing hydrocarbons that are dissociated at a high temperature, while depositing, on the coal being coked, graphite which cements the coal particles on the mass contracting.

Pitch, which leaves a coke as a residue of distillation, has not given successful results for coking poor coals, while the hydrocarbons give rise to a magma of graphitic crystals, which explains why pitch exerts no cementing effect. The compactness of coke is a function of the difference between the expansion-coefficient of coal while being coked and the contraction-coefficient of coke; or, in other words, the coke is so much the more compact as the contraction of the coal charged is greater. It follows that all coals, which contract on being carbonized, are capable of yielding blast-furnace coke, provided that the hydrocarbons, in which they are deficient, be added and thoroughly mixed with the coal.

It is this special hydrocarbon which Mr. Hennebutte produces under the name of "cement," and which is sent out in the form of an impalpable black powder or in the liquid state. His process is suitable for

all coke-ovens, without any modification being required; but one condition (not peculiar, however, to the Hennebutte method) is imperative, namely, that the cement be intimately mixed with the charged coal. This method of coking is moreover of general application, for it permits of coking lignites, non-bituminous coals, and also those burning with a long flame, the nature and percentage of the cement being the only variation.

At the Houssu collieries satisfactory trials were made with coals unsuitable for coking, and also with coking-coals that formerly received an enrichment which is now superseded by a fixed quantity of cement. At that time the company mixed from 10 to 20 per cent. of coal-dust from the Couchant de Mons district with its own coking-coals containing 15 per cent. of volatile matter and 12¼ per cent. of ash. Half the quantity received the addition of 3 per cent. of cement, increasing the volatile matter by 1 per cent.; and the other half, enriched by the coal-dust, had exactly the same percentage of volatile matter. The coke obtained in both cases was irreproachable, while the ash-content in the sample made with coal-dust was greater, as was necessarily the case, the dust showing 17 per cent. of ash while the cement contains none. Moreover the Hennebutte method gives 2·4 per cent. more coke, while the proportion of large coke is 2·63 per cent. greater.

The cement creates a high temperature, so that coals not rich in volatile matter may be coked. At the present time 30 per cent. of the coal charged contains only 14½ per cent. of volatile matter; and the proportion of cement does not exceed 2 per cent. of the charge. The improved yield more than pays for the cost of the cement; and, as regards carriage, coke-producers away from collieries will find a considerable saving, while they are unaffected by fluctuations in the market, as the cost of the cement scarcely varies.

J. W. P.

THE SELIGSOHN AMALGAMATION PROCESS.

An Improved Amalgamation Process. *By* A. CHESTER BEATTY. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., page* 108, *with* 1 *illustration in the text.*

The object of this process is to increase the percentage of gold-extraction by amalgamation, by passing ammoniated air, mixed with either chlorine or bromine, into wet ore-pulp. These gases are introduced as the pulp issues from a stamp-battery, Huntington mill, or other crushing machinery. The chemistry of the process is somewhat obscure, but the result in nearly all cases has been to effect a marked increase in the percentage of gold extracted by amalgamation.

X. Y. Z.

THE HICKS GOLD-RECOVERY PROCESS.

The Dahlonega Consolidated Gold Mining Company's Plant. *By* PROF. WILBER COLVIN. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., page* 202, *with* 1 *illustration in the text.*

Much of the ore put through the mill was of a low grade, taken out in development-work. It is neither soft ore, nor distinctively sulphuret or hard ore; and it seems to be the most difficult of any from which to save the gold. Neither the plates, nor the concentrators catch it, and it washes over and is lost. Ore that assayed £1 13s. to £2 10s. (8 to 12 dollars) per ton yielded only 8s. 4d. to 12s. 6d. (2 to 3 dollars) per ton.

For several months tests have been made with the Hicks process. Essentially, it consists in subjecting the ore-pulp as it comes from the mill-stamps to a mercury bath, as it is agitated in a closed barrel at a certain temperature and with devices to keep the mercury from flouring. The experiments have been entirely successful, and ores from which the mill had been saving 8s. 4d. to 12s. 6d. (2 to 3 dollars) per ton yielded £2 6s. to £2 10s. (11 to 12 dollars) per ton under this process. X. Y. Z.

THE TREATMENT OF BATTERY-SLIMES BY FILTER-PRESSES.

Notes on the Treatment of Slimes by Filter-presses. By CLEMENT DIXON. *Journal of the Chemical and Metallurgical Society of South Africa*, 1902. *vol. iii., pages* 13-14.

Good work is now being done with the filter-press in Western Australia, New Zealand, and other places, where the decantation-process is not viewed with favour.

The 6 tons filter-press, made by Mr. Dehne, Halle-on-Saale, Germany, is an excellent machine, and will hold 6 tons of dry slimes and about 3 tons of moisture. As the press could be re-charged, say every 2 hours, each machine of this size has a capacity of from 60 to 70 tons of dry slimes in 24 hours.

In establishing the filter-press on a slimes-works, the most important detail is to find out by experiments what thickness of slimes-cake should be made, or, in other words, what is the best depth to make the hollow frames, so as to ensure that the cakes will be uniformly permeable to wash solutions; this thickness, of course, depends on the nature of the ore and the fissures of crushing. A cake, 3 inches thick, would probably be found suitable for the Rand.

There are two principal methods of dealing with slimes in filter-presses:—(1) The slimes (separated by spitzlutten, settled in V boxes and settling vats) are agitated with weak cyanide solution of the required strength; and, so soon as the solution of the gold is practically complete, the pulp is forced into the presses, so as to separate the gold-bearing solution from the slimes. Then weak-wash or water is forced through the cakes, so as to displace the remaining gold-bearing solution. (2) The solution of the gold may be effected in the filter-presses (without previous agitation) by charging the presses with slimes and then forcing cyanide solution through the slimes-cakes until the highest commercial extraction of the gold is obtained. Then displace the gold-solution by weak-wash or water.

Both these methods are in use in Western Australia, but the choice must be determined by experiment on the slimes to be treated. The first method is adopted with every success by the largest reduction-works in New Zealand. There is a certain accumulation of weak solution; but, in practice, it is not necessary to throw away much of any valuable solution. It may be used for washes on the sand-plant, as well as for washing the press-cakes, before they are thrown out. At the Waihi works in New Zealand, up to the end of June, 1902, the company had treated about 50,000 tons of slimes and had obtained an extraction of over 90 per cent. In New Zealand, the charges contain from 12 to 13 dwts. and the residues 1 dwt. or less. The bulk of the solution used is 1·5 to 1 per cent. The strength of solution used in New Zealand is 0·1 per cent.

The following figures, for 1901, were obtained on the Kalgoorlie gold-fields, Western Australia:—

Name of Mine.	Battery.		Sands.		Slimes.	
	Cost per Ton.	Yield of Bullion per Ton.	Cost per Ton.	Yield of Bullion per Ton.	Cost per Ton.	Yield of Bullion per Ton.
	s. d.	Dwts.	s. d.	Dwts.	s. d.	Dwts.
Lake View Consols ...	6 10·5	13·8	5 11·0	10·6	7 0·0	6·6
Ivanhoe Gold Corporation	6 8·0	11·5	5 2·8	1·5	6 7·3	8·1
Golden Horse-shoe Estate	9 7·7	14·9	6 2·3	10·7	10 1·4	8·8

J. W.

THE LEAD-SMELTING OF ZINC-GOLD SLIMES.

The Lead-smelting of Zinc-gold Slimes. *By* P. S. TAVENER. *Journal of the Chemical and Metallurgical Society of South Africa*, 1902, *vol. iii., pages* 70-77, *and* 1 *plate.*

This process was introduced by the author in August, 1899, and since the resumption of milling at the Bonanza, Limited, Witwatersrand, some 14 months ago, it has been continuously in operation. The lead-smelting may be described as a scorification-assay conducted on a large scale, the zinc-slimes being melted and the gold recovered in lead-bullion. The lead-bullion is then cupelled or, to use a better term, refined.

In the clean-up, all the precipitate is at once pumped from the clean-up tub into the filter-press: the fine zinc which remains at the bottom of the tub being heaped up on one side and allowed to drain for about ½ hour, when it is ready for the smelting-room. The filter-press is cleaned out and the moist cakes are taken to the furnace where both slimes and fine zinc are put in separate trays into a drying oven, and warmed through for 15 minutes, the fine zinc being kept separate from the pressed slime.

In charging the furnace, the slime is first dealt with. After warming in the drying oven, it is at once rubbed through a sieve (4 holes to the linear inch), and then roughly weighed for fluxing, the necessary fluxes having been previously mixed. The flux is added to the slime and the whole passed through a sieve, to ensure thorough mixing, and then shovelled direct into the furnace. When all the filter-press slime is charged, the fine zinc is dealt with in the same way and put into the furnace on the top of the slime, in order to prevent loss by dusting, and also to have the greater portion of the litharge present on the top of the charge.

The fluxes used are:—Residue-assay slag and commercial litharge (the former is a bye-product from the assay-office and costs nothing).

The author has found that the following, with little variation, will give satisfactory fusion and clean slag:—Slag, 25 to 30 per cent., made up of 10 per cent. assay-slag, the balance being equal quantities of old slag and scalings from the pots of a previous smelt. Roughly, the proportions of fluxes are:—For slime, 100 parts by weight use litharge, 60 parts; assay-slag, 10 to 15 parts; slag previously used, 10 to 15 parts; and silica, 5 to 10 parts by weight. For fine zinc, 100 parts of weight, use litharge, 150 parts and slag 20 parts by weight. A few trials made on a small scale in assay-office fires would quickly show the best proportions to use.

The lead-bullion obtained should not contain more than 8 per cent., or at most 10 per cent., of fine gold.

As a reducing agent for the slime, 1 per cent. of sawdust on the weight of litharge is added, or, if more than 60 per cent. of litharge has been used, 1½ to 2 per cent. of sawdust is necessary.

The cupelling furnace is built with ordinary local fire-bricks: the blast being obtained by a Root blower, small size, driven at a speed of 1,600 revolutions a minute. J. W.

THE SMELTING AND REFINING OF ZINC-GOLD SLIMES.

The Smelting and Refining of Zinc-gold Slimes. *By* E. H. JOHNSON *and* W. A. CALDECOTT. *Journal of the Chemical and Metallurgical Society of South Africa*, 1902, *vol. iii., pages* 21-24.

An epoch of advance, in the above processes, dates from Mr. A. F. Crosse's statement in June, 1898, to this society, that he and Mr. E. H. Johnson had independently succeeded in producing pure bullion from the zinc-precipitate of the cyanide process. The point of similarity in the two methods was the use of manganese dioxide in the flux, and the points of divergence were the use by Mr. Crosse of a clay-lined crucible and silicate of soda; and by Mr. E. H. Johnson of a replaceable clay-liner to the crucible and sand as the source of silica. The zinc-gold slimes, having been efficiently treated by dilute sulphuric acid and thoroughly washed, are calcined at a fairly high temperature without any stirring of the dried slimes.

The following analysis, made recently by Mr. A. Whitby, of acid-treated and calcined slimes, illustrates the Rand product:—Gold, 34·50; silver, 4·75; lead, 12·50; copper, 2·55; ferric oxide, 3·65; zinc oxide, 7·00; sulphur trioxide, 6·95; nickel oxide, 1·00; silica, 21·00 per cent.; a total of 93·90 per cent., leaving the organic matter undetermined.

The following is a basis of flux, which the authors have used for some time, varying the proportions to suit special conditions:—To slimes, 100 parts: use fused borax, 20 to 35 parts; manganese dioxide, 20 to 40 parts; and sand, 15 to 40 parts. A little fluorspar may be added to assist fluidity.

At a recent smelting at the Robinson Deep mine, 202·8 pounds of calcined slimes yielded 1,016·1 troy ounces of fine gold in the total bullion. The bullion contained 970 gold and silver per 1,000 parts. The weight of slag produced was 286 pounds; it ran fluid and almost neutral, and contained 0·9 ounce of fine gold and 5·5 ounces of silver. J. W.

LOSSES OF SILVER IN CUPELLING.

The Losses of Silver in Cupelling with varying Amounts of Lead and Silver. *By* W. H. KAUFFMAN. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 829-830.

A series of experiments were made to determine the losses sustained under the following conditions:—(1) With the same amounts of silver and varying amounts of lead; (2) with varying amounts of silver, from 25 to 200 milligrammes; (3) the influence of copper on the results; (4) the influence of varying temperatures; and (5) the influence of various grades of cupels. The apparatus and *modus operandi* of the experiments are described in the text and the results embodied in a table.

Some large variations in losses occur by difference of temperature, even where the conditions of cupellation are otherwise the same. Small differences of temperature cause surprising differences in the results, and an excessive heat will cause greater losses than any other variation in the conditions of cupellation. The following conclusions are drawn from the tabulated results of the experiments:—(1) The percentage-loss of silver is greater in cupelling small amounts of silver than when larger amounts are cupelled. (2) The loss is appreciably greater when the lead-button weighs 25 grammes than when it weighs but 5 grammes, except in the case of the 25 milligrammes silver-button. With 10 and 15 gramme buttons, the losses are generally smaller than with 25 gramme buttons, and larger than with 5 gramme buttons. (3) Similar conclusions are drawn regarding buttons containing small amounts of copper; the losses are not increased by the presence of copper up to 100 milligrammes. (4) With potash-and-borax cupels, the losses are in general the same as when water-cupels are used. (5) Excessive heat causes greater losses than large amounts of lead, and (6) the smallest losses occur when a small lead-button is cupelled at a low temperature. X. Y. Z.

ALUMINIUM-ZINC ALLOYS.

Aluminium-zinc Alloys. *By* Dr. Joseph W. Richards. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 715-716.

Many contradictory statements having been made concerning these alloys, the writer lays it down, as a rule obtained from the experience of himself and others, that none of these alloys possess mechanically useful properties unless the aluminium-content exceed the zinc. All alloys containing from 1 to 10 parts of zinc with 1 part of aluminium may be classed as mechanically valueless. On the other hand, alloys containing more aluminium than zinc first commence to possess valuable properties.

The alloy of 2 parts of aluminium to 1 part of zinc is a remarkable alloy, being equal in strength to cast iron, it melts at about 800° Fahr., does not readily oxidize, takes a fine finish, and perfectly fills the joints of the mould; it is, like cast-iron, brittle, but resists corrosion well. At present, however, there is no difficulty in reaching a tensile strength of 40,000 pounds in castings. In its characteristics, it closely resembles a high-carbon steel, being very rigid, slightly elastic, and breaking short with a fine-grained fracture. It works well under the tools, in turning or boring, not requiring lubrication. It is the hardest and strongest of the available alloys of these metals, takes a high polish and keeps its colour very well. Its specific gravity is 3·8, and calculation shows the remarkable contraction of 17 per cent. during the alloying, which suggests the cause of its great strength. Numerous uses for such an alloy will suggest themselves to every mechanical engineer.

The alloy of 3 parts of aluminium to 1 part of zinc is the most generally useful of all the aluminium-zinc alloys. Remarkably clean and sharp castings can be made with it, and when properly made from pure metals it is all that could be desired in its working qualities, being equal to the finest brass in the lathe, under the drill, and in not clogging the file. It casts sound, takes a high polish, and has as fine a colour as the best aluminium. It is not so hard and short, nor quite so strong as the 33 per

cent. zinc alloy, but has superseded it for most purposes because of its better working qualities and greater reliability under shock. It is non-magnetic, and therefore particularly useful in the manufacture of scientific instruments.

Below 25 per cent. of zinc, the strength and hardness of the alloys decrease rapidly, and at 15 per cent. the alloy can be forged, rolled or drawn. Mechanical tests of this latter alloy after working have not yet been made. X. Y. Z.

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ALLOYS AS SOLUTIONS.

Alloys as Solutions. *By* JOHN ALEXANDER MATTHEWS. *The Engineering and Mining Journal* [*New York*], 1901, *vol. lxxii., pages* 819-822 *and* 851-854, *with* 15 *illustrations in the text.*

This paper is valuable, as furnishing a concise account of the present position and prospects of alloys research. The author states that it is truly remarkable that any class of substances so long known and studied as alloys should have so completely hidden the secrets of their inner molecular constitution until within the last decade or so. The causes of the rapid advance in this direction during the last few years are principally found in our increased knowledge of solutions, the development of metallography, and in the improvements of pyrometry. The writer deals very fully with the resemblance between alloys and solutions.

It is remarked that text-books of physical chemistry contain much information about the solution of gases in liquids, liquids in liquids, and solids in liquids, but are for the most part silent on the subject of the solution of solids in solids. Nevertheless, it is this conception of alloys as solutions (solid solutions) that has been steadily progressing in favour during recent years. This position is explained and substantiated by an account of the experimental results obtained by many recent investigators. Because certain bodies are called solid, it is not implied thereby that molecular mobility is entirely absent; the difference in mobility of the molecules in solids and those in liquids is one of degree only. Metals in the so-called solid state tend to evaporate, and metals in the same state unquestionably diffuse into each other. The investigation of recent years has demonstrated many points of resemblance between metallic mixtures and ordinary solutions:—One metal diffuses into another like a salt into water; like two liquids, they may be perfectly mixable or form layers; the layers are not pure, but each contains a little of the other in solution; and in general, the solubility increases with the temperatures; the metals flow under pressure; they may or may not react chemically when brought into intimate association; the molecular mobility increases with the temperature; the phenomena observed on the cooling of binary alloys strongly suggest the phenomena observed on the freezing of salt solutions; the depression of the freezing-point of one metal when another is added follows the laws of Coppet and Raoult; and, in fact, to point out all the similarities between alloys and ordinary solutions would be to give our present conception of the constitution of alloys.

The great value of this conception of alloys as solutions is that it enables the process of the production of alloys to be directed along definite lines determined by intelligible principles. The production of alloys in the past has been by the very wasteful method of chance, but the writer now

hopes to see it develop into an exact science. Indeed, many of the illustrations furnished in the text are purely mathematical figures. One of these is a cooling-curve drawn to the co-ordinates of time and temperature. During the cooling of a molten alloy, various constituents may crystallize out successively; definite compounds stable at high temperatures may split up as the temperature falls, or new compounds impossible at high temperatures may be formed at lower temperatures. All such molecular changes are accompanied by corresponding thermal effects, such as the liberation or absorption of heat. By accurate measurement of the temperatures at those points most valuable information is obtained in regard to the molecular movements in the mass. This information is obtained by means of the cooling-curve. Then, again, in many pairs of metals, the relative solubility is a function of the temperature, from which it appears likely that at some particular temperature solubility is complete. This particular temperature is found by a critical curve, illustrated and described in the text.

The freezing-point curve is a third mathematical drawing capable of rendering great service in alloys research, and it depends on the principle that the freezing-points of metals follow laws well known in connection with fluids. The depression of the freezing-point of one metal when another is added follows the laws of Coppet and Raoult, namely:—(1) For moderate concentration the fall of freezing-point is proportional to the weight of dissolved substance present in a constant weight of solvent; and (2) when the falls produced in the same solvent by different metals are compared, it is found that a molecular weight of a dissolved metal produces the same fall whatever the metal may be. Now, the cooling-curve, above mentioned, results during the cooling of a single alloy, the co-ordinates being time and temperature. When a series of such curves are obtained for any pair of metals mixed in all proportions from 0 to 100 per cent. of one in 100 to 0 per cent. of the other, and the critical points are plotted in a diagram whose co-ordinates are temperature and composition, we get what is known as a freezing-point curve. That is, the points at which all possible combinations of the two metals freeze are indicated more or less accurately: the accuracy of the whole curve being greater or less as the number of points on the curve actually determined is greater or less.

After describing the uses of these various curves, the writer concludes by remarking that when many sets of complete freezing-point curves have been determined, and the alloys of the series have been examined metallographically, and when the ordinary physical tests have been accurately applied to them, we may then be able to generalize and to predict properties of new pairs of metals as well as to set out intelligently to produce new and useful alloys. X. Y. Z.

CEMENT MADE FROM BLAST-FURNACE SLAG.

Die Verarbeitung von Schlacken auf Zement. *By* DR. — STEGER. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im Preussischen Staate*, 1903, *vol. li., Abhandlungen, pages* 65-71, *with* 3 *figures in the text.*

Certain calcareous blast-furnace slags, especially at these works where raw pig-iron is produced, approximate in their composition to that of Portland cement; and to become exactly identical with it in composition they need only to be supplemented, according to circumstances, by certain proportions of limestone, clay, or aluminous substances such as bauxite.

The mixture of slag, etc., is ground very fine, well mixed together, moistened sufficiently to be made up into bricks, and then burnt. Actual melting does not take place, as the proportion of lime is calculated to prevent this. The calcined bricks are pulverized, and yield a Portland cement of unexceptional quality.

But the hardness of the slag makes grinding a costly process, sufficiently so in some cases to prevent the method just decribed from being, economically speaking, workable. Another system has been suggested: the molten slag fresh tapped from the furnace, is to be mixed at once with the necessary proportions of pulverized limestone or clay, well stirred up, and converted direct into cement. The fundamental objection appears to be that the consequent reduction of temperature of the whole mass is too rapid to permit of uniformly satisfactory results.

Slag-cements are now usually prepared as follows:—The slag flowing out of the blast-furnace is led into water kept as cold as possible, and breaks up consequently into a multitude of small grains. This granular slag is scooped up out of the cooling-pond by appropriate apparatus and conveyed thence to driers, where it is freed from water (the percentage of which is generally as high as 60). This drying process is fairly difficult and costly. The slag is then ground to a fine flour, and mixed with previously slacked lime into what is (to all intents and purposes) ordinary cement. A little moistening with water is sufficient to harden it gradually into a solid body.

In order to avoid the difficulties of the drying process above described, one method is, by means of blowing air through the molten slag, to convert it into slag-wool. This reduces the cost of grinding and moreover induces by oxidation certain chemical changes in the slag which are not without influence on its hydraulic qualities. The sharp, angular slag-dust is very dangerous to the respiratory organs of the workmen, and therefore all the apparatus has to be so planned as to work without spreading dust in the surrounding atmosphere.

The chief impurity present in slag, of which it is desirable to get rid when converting the slag into cement, is sulphur, and the author describes briefly the process by which the sulphur is finally eliminated in the form of gypsum.

One of the most recent advances made in the manufacture of slag-cement, consists in dispensing with any substances beyond the slag itself, by treating the molten mass, conveyed into appropriate recipients, with atmospheric air. A description, with explanatory figures, of the new process is given. It is interesting to note that while Portland cement contains from 57 to 66 parts of lime by weight, the air-treated slag only contains from 40 to 48 such parts, and the modern theory is that cement may safely contain a far smaller proportion of lime than has been hitherto thought indispensable.

The recent successful use of rotating furnaces in making ordinary Portland cement has suggested the burning of a mixture of highly basic slag (which soon crumbles to dust when exposed to the atmosphere) with powdered limestone or quicklime, in a rotating furnace. In this way a cement is cheaply obtained, which can be used without further preparation. L. L. B.

BOILER-ACCIDENTS IN FRANCE IN 1900 AND 1901.

(1) *Bulletin des Accidents d'Appareils à Vapeur survenus pendant l'Anneé 1900.* ANON. *Annales des Mines*, 1901, *series* 9, *vol. xx.*, *pages* 548-562, *and* 2 *plates*.

In 1900, 31 boiler-accidents took place in France, resulting in the deaths of 15 persons and more or less serious injury to 31 others.

The only one of these accidents that took place in a mine or quarry was that which occurred at the Escarpelle colliery, Nord. On April 7th, 1900, a copper waste-pipe, which was in an unsound condition, burst over a length of 14 inches, in the part which lay between the generator and the waste stopcock. The water, spirting out of the ruptured tube into the rear portion of the furnace, determined a sudden rush of flame which scorched badly the stoker.

Out of the total number of 31 accidents referred to, 14 took place in water-tube boilers and these account for 7 out of the total of 15 deaths. In the attribution of causes, 5 accidents are set down to defective installation, 14 to defective maintenance, 13 to bad usage and 4 undetermined. As this accounts for 36 instead of 31 cases, the inference is that in 5 instances two causes combined to produce the accident. Four accidents occurred in railway or tramway-locomotives, and three on steamboats.

(2) *Bulletin des Accidents d'Appareils à Vapeur survenus pendant l'Année 1901.* ANON. *Annales des Mines*, 1902, *series* 10, *vol. ii.*, *pages* 550-564, *and* 5 *plates*.

Of the 36 boiler-accidents which were recorded in France during 1901, 3 took place in coal-mines.

At Ferfay colliery, Pas de Calais, on May 2nd, 1901, a horizontal boiler fed with pit-water (which is in this colliery highly charged, at times, with saline matter) suddenly exploded, blowing the furnace-doors open, and scalding the stoker to death. The accident was caused by a rent in the boiler-plates, which had got superheated in certain parts, as a consequence of the deposition within them of a thick crust of sodium chloride and calcium sulphate.

At Aniche collieries, Nord, on July 19th, 1901, an accident occurred in No. 4 of a battery of four cylindrical horizontal boilers. No. 4 boiler was being cleaned, and in order to cool the atmosphere within it cold water was injected by opening the feed-valve. No. 1 boiler was being fired: its feed-valve also was open, and there was only the stop-valve to prevent a rush of boiling water thence into No. 4. Unfortunately this stop-valve failed to perform its work, and boiling water poured into No. 4 upon the luckless workmen who were busy cleaning the boiler. Three were badly scalded, and one more slightly so. The failure of the stop-valve would have had no disastrous results, if the workmen had been ordered out before proceeding to turn on the feed-water.

At Prades-Nieigles colliery, Ardèche, a boiler burst on September 9th, 1901, and 2 workmen sustained slight injuries in making their escape. The boiler (horizontal, cylindrical, of the reversed-flame type) was in a very bad condition. It was fed with very acid water taken from a brook, into which flowed the pit-waters from a highly-pyritous coal-mine. Hence, such excessive corrosion of the boiler-plates that leakages were frequent, and finally a tremendous rent was opened up in them on the date mentioned.

Apart from coal-mines, boiler-explosions took place in 6 railway-locomotives, in 6 steamboats (fatalities more numerous in these than in any

other class of accident), in 4 weaving and spinning sheds, and the remainder in various mills, factories, power-stations, etc.

The total number of lives lost was 27, and of persons seriously injured 35. The boilers which burst were in 11 cases non-tubular, in 14 cases provided with smoke-tubes, and in 7 cases with water-tubes.

No less than 19 of the accidents are attributed to the bad state of repair of the boilers, 6 are attributed to original defects of installation, 12 to misuse (in various degrees) of the boilers, and in 3 cases the blame cannot be definitely apportioned. L. L. B.

EXPERIMENTS WITH CENTRAL CONDENSING-PLANT AT COLLIERIES.

Versuche und Beobachtungen an Centralkondensationen auf Steinkohlenzechen. By ERNST STACH. *Glückauf*, 1902, *vol. xxxviii., pages* 277-289, *and* 3 *plates.*

Exhaustive experiments were made at Dorstfeld, the Graf Schwerin and Herne collieries, with central condensers constructed by the Maschinenfabrik Grevenbroich, Messrs. Balcke & Company and Messrs. L. Schwarz & Company, respectively. The results are considered to shew that, in all cases, a considerable saving of fuel is effected by this kind of plant. The actual power consumed by the condensing plant may be economized by adapting the working of the circulation-pump to the load; and it is advisable to employ two pumps that can be worked together or separately as required. Too much stress is generally laid on a high vacuum, with the result that the plant is usually larger than is really necessary, although a large air-pump is rather an advantage than otherwise.

The amount of water required for cooling may be calculated by the formula: $n=(607-0{\cdot}7t')/(t-t_0)$, in which n represents the factor to be multiplied by the weight of steam to give the weight of water needed; t' is the temperature of the steam to be condensed; t, that of the effluent cooling water, and t_0, the initial temperature of the latter. A 90 per cent. vacuum corresponds to a steam-temperature of about 115° Fahr. (46° Cent.) and an 80 per cent. vacuum to about 140° Fahr. (60° Cent.). Assuming that the temperature of the effluent water is 2° Cent. lower than that of the steam, and that the temperature cannot be reduced below 30° Cent. in warm, damp weather, then the value of n will be, for a 90 per cent. vacuum, 41, and for an 80 per cent. vacuum, 20. Hence, in order to obtain an increase of 10 per cent. in the vacuum, the water-pump must do 105 per cent. more work, the result being that the power consumed by the plant is increased from about 3 per cent. of the total efficiency to 4¼ per cent., which means higher working expenses, in addition to the greater prime cost. Moreover, with a lower vacuum, the condensed water has a higher temperature for return to the boiler, while the increased consumption of steam is unimportant when high admission-pressures (6 to 10 atmospheres) are employed.

In some cases, the mistake is made of omitting to connect old or distant engines to the central condenser. This should always be done, since the outlay on repairs will soon be repaid by the improved efficiency of the whole installation. Another reason for being satisfied with a lower vacuum is that for three-quarters of the year the lower temperature of the cooling water enables a higher vacuum to be readily obtained, and thus the average for the year is raised. C. S.

SUPERHEAT OF STEAM.

Wie hoch soll der Dampf überhitzt werden, um einen minimalen Dampf- und Heizmaterialverbrauch bei den Dampfmaschinen zu erzielen. By JOSEF JEDLIČKA. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., page* 52.

The data given respecting the consumption of steam, feed-water and heat with saturated steam, are calculated without taking count of the priming in the steam. According to the type of boiler used, and the evaporation, the priming may vary from 3 to 12 per cent. of the total feed-water. The heat of liquefaction required to maintain this condition is wasted, and can only be partly recovered by collecting the priming water, and using it to feed the boiler. For this reason the values showing the increased economy of steam with a given degree of superheat, as against saturated steam, should be higher, and the co-efficients of heat lower than those given in the tables. The consumption of steam, feed-water and heat are also calculated without reference to the lesser specific weight of superheated steam, which depends on the temperature of superheat. If this circumstance be taken into account, the actual minimum values will be about 8 per cent. less than those given in the tables, because at constant pressure the specific weights are in inverse proportion to the absolute temperatures.

In a single-cylindered steam-jacketted condensing engine of 50 indicated horsepower, working with steam at a pressure of 8 atmospheres and superheated to 477° Fahr., the economy obtained would be 8·2 per cent., the consumption of steam 10·3 pounds and of feed-water 10·5 pounds per indicated horsepower-hour. For such an engine, the writer shows in tabular form the consumption of feed-water at varying powers and pressures, working with and without a steam-jacket, condensing and non-condensing. The co-efficients of heat given in the former tables are 1·25 times higher than they would be, if the above conditions are taken into account. In a three-cylindered condensing steam-engine of 1,000 horsepower, working at a pressure of 12 atmospheres, and the steam superheated to 486° Fahr., this co-efficient would be 21 per cent. The smaller specific weight of the steam has little effect on the temperature of superheat. E. M. D.

A HIGH-VOLTAGE TRANSMISSION-PLANT.

The 50,000 Volt Transmission-plant of the Missouri River Power Company. By W. G. MCCONNON. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 789-790, *with 7 illustrations in the text.*

The power-house of the Missouri River Power Company is located at Cañon Ferry, a little town at the mouth of Blackrock cañon, on the Missouri river, about 20 miles nearly due east of Helena, Montana.

A dam about 480 feet long, and designed to give a 30 feet head of water, has been thrown across the river at tne mouth of the cañon. The amount of water in the river at this point is estimated to develop 10,000 horsepower all the year round. The work was begun 4 years ago, but considerable extensions were initiated in the fall of 1900. The power-plant now consists of ten direct-connected generators of 750 kilowatts of the three-phase type, with four exciters, of which two are machines of 90 kilowatts direct-connected to separate wheels, one a machine of 225 kilowatts with

a separate wheel, and one motor-driven generator of 115 kilowatts. The water-wheels are horizontal McCormack wheels, 45 inches in diameter, and each wheel has its own governor, seven being Lombard, and three Replogle governors.

The feature distinguishing this from all other transmission plants is the high pressure of 50,000 volts employed on the new lines to Butte. The distance by pole-line to Butte is 65 miles. The line itself consists of two lines of poles about 50 feet apart. Each line consists of three seven-strand copper cables arranged in an equilateral triangle with a spacing of 78 inches between the centres. These cables are transposed five times between Cañon Ferry and Butte. The average distance between the poles is 110 feet. It has been found, after exhaustive tests, that a thoroughly dry oak pin of the length used in this installation, boiled in paraffin, will readily hold up alone under 50,000 volts. A glass sleeve below the insulator is used to keep as great a length as possible of the pin dry under all conditions of weather.

The transformers at each end of the line consist of six oil-insulated transformers of 950 kilowatts with water-cooling coils in the cases. Those at Cañon Ferry transform from 550 to 50,000 volts, and at Butte, the step-down transformer is made from 50,000 to 2,200 volts. It is noteworthy that since the starting of the plant, there has been no mishap of any kind to the line of apparatus. X. Y. Z.

ELECTRIC POWER IN CALIFORNIA.

Electric Power-plants in the Mining Districts of Northern California. *By* G. P. GRIMSLEY. *The Engineering and Mining Journal [New York]*, 1901, *vol. lxxii., pages* 270-271, 300-301 *and* 330, *with* 2 *maps and* 5 *illustrations in the text.*

One of the most notable plants described by the writer is that now nearly completed by the Standard Electric Company.

The water-storage basins, including a natural rock-basin on Bear river below the Blue Lakes, have a capacity of 9,500,000,000 gallons. The water runs from this lake to the Mokelumne river, which flows over a granite bed, and in a deep granite-cañon which also carries the water from the upper lakes to the old Amador canal. This canal has a capacity of 3,000 miner's inches of water controlled by 82 flumes, and with a grade of 8 feet to the mile, giving a velocity of 300 feet per minute. A new ditch has been constructed with a capacity of 7,500 miner's inches and with 3 miles of flumes, some of which are 80 feet above ground-level. A large storage-reservoir has been built above the power-house, with a capacity sufficient to run the plant for 10 days. This will be used in case of breakage in the pipe-lines, and may be utilized in carrying peak-loads at certain times of the day. The new ditch connects by a branch with the reservoir, and also runs direct to the power-house with a fall of 1,482 feet. The old ditch too connects with the reservoir and power-house.

The power-house will have an equipment of seven Stanley generators of 3,000 kilowatts connected with seven impulse water-wheels of the Pelton type. The current is conducted into the transformer-room of the building, where the initial voltage of 2,200 will be stepped up to 60,000. The wires then pass to a separate building equipped with lightning-arresters, and out on the lines to Stockton, Oakland, San José, and the smaller towns along

the way. The line to San José will be continued around the bay to San Francisco, and will have a total length of 150 miles. This will be the longest operating transmission-line in the world, carrying the highest voltage, and acquiring power under one of the highest heads of water.

Storage batteries at Oakland, San José and San Francisco will carry the load in case of temporary shut-down of the plant, and will carry peak-loads as well as regulate the current on the entire system. The plant when completed next fall will have a capacity of 20,000 horsepower, and will cost about £1,200,000 (5,000,000 dollars). By building dams in Alpine county across Cold creek, Deer valley and Little Bear river, the capacity may be increased to 35,000 horsepower. When the plant is completed, electric power will be used in most of the mines in this district.

A number of other plants are described by the writer, and the appended maps are very useful, as showing the magnitude of the undertakings, and their probably far-reaching effects on mining development in Northern California. X. Y. Z.

AN ELECTRIC WINDING-ENGINE.

Ueber ein neues System elektrischer Schacht-Fördermaschinen. By HANS BANSEN. *Glückauf*, 1902, *vol. xxxviii., pages* 175-177, *with* 1 *figure in the text.*

In the electric winding-engine introduced by the Union Elektrizitäts-Gesellschaft, Berlin, the usual resistances for altering the speed of the motor are replaced by a dynamo which can be caused to work in conjunction with or against the motor. A continuous current of, say, 110 volts actuates the winding motor, and also excites the field of the supplementary machine, the intensity in the latter case being variable between 0 and 110 volts by means of resistances. As the supply of current to the supplementary machine can be reversed, the tension may be varied between + 110 volts and − 110 volts.

In starting to wind the cage, the tension in the secondary machine is in maximum opposition to that of the winding motor, which therefore remains at rest, but as the opposing tension is gradually reduced by the starting rheostat, the winding motor begins to run at progressively increasing speed until the full tension is reached in the latter. The supplementary machine may then be short-circuited, or else employed to assist the winding motor and increase the tension to a maximum of 220 volts. To reduce speed, a shunt-regulating resistance reverses the current in the supplementary machine, whereupon the winding motor acts as a dynamo and sends an opposing current into the line-circuit, its speed being correspondingly reduced. During the short interval occupied in overcoming the force of inertia due to the higher speed, the winding motor acts as a primary machine and supplies, through the supplementary machine, a current opposing that of the line. In this way all waste of the line-current during alterations of speed is precluded. C. S.

ELECTRIC PUMPING-PLANT AT THE FIRMINY COLLIERY.

Installation électrique d'Épuisement au Puits Monterrad No. 2: Division de la Malafolie des Mines de Firminy. By — DENOGENT. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 61-62.

The pump is of the Jandin normal horizontal type; and electric driving was adopted, on account of its simplicity and the relatively slight cost of the plant.

When the pump makes 100 revolutions per minute, the motor gives out 182 horsepower; and under this load the efficiency of the motor is 94 per cent. The leakage in the conductor is 2½ per cent.; and the efficiency of the alternator is 90 per cent. with, and 92·5 per cent. without, the exciter; so that the total yield of the electric plant is (0·94 × 0·975 × 0·9 =) 0·825.

Long-continued trials at various times have given the following mean results:—Mechanical yield of the pump, 87 per cent.; volumetric yield of pump, 94 to 97 per cent.; loss of load in the delivery-pipe, 3 per cent.; and the total efficiency, or the ratio between the indicated power of the steam-engine and the work in the water raised, 60·6 per cent. The total efficiency is, however, 63 per cent. if the power absorbed by the centrifugal pump for condensation be deducted; and the consumption of steam per horsepower per hour in the water raised is 32 pounds (14·6 kilogrammes).

The total cost of the plant was about £14,000 (350,000 francs).

J. W. P.

ELECTRIC PUMPING-PLANT AT THE PORTES COLLIERY.

Installation électrique des Mines de Portes. By — LECAMUS. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 4-10, *and* 3 *plates.*

The electric generating-station comprises a single-cylinder condensing Collman engine of 150 horsepower, driving a Siemens-Halske flywheel alternator. In this engine the distribution-valves, actuated by eccentrics, are constructed and arranged so as to avoid shock when they come down upon their seats, without, however, wire-drawing the steam, while at the same time effecting a rapid closing, due to a special cataract. The closing, however, slackens as the valve approaches its seat.

The three-phase alternating current is produced at a tension of 1,000 volts; and the alternator can give out normally 110 kilowatts. There is also a static transformer of 3 kilowatts supplying a current of 120 volts to a motor of 4 horsepower, driving a Rateau centrifugal pump, which raises the condensation-water to the top of a refrigerator.

The line connecting the station on the surface with the underground motor is a cable of three parallel conductors of 35 square millimetres section, covered with lead and armoured with steel wires.

The pump is driven, through an elastic coupling, by an asynchronous motor with a revolving field, the inductor being fixed and the armature movable. The reduction of speed is obtained by steel pinions and cast-iron spur-wheels with helical teeth. The suction and delivery-valves of the pump are in two stages, with a rise of ⅜ inch (1 centimetre). The underground pump raises 24,200 gallons (110 cubic metres) per hour to a height of 656 feet (200 metres), showing with its motor an efficiency of 79 per cent., and the cost of the kilowatt-hour is not 3 farthings (0·073 franc).

The centrifugal pump, which has worked since September, 1901, raises 17,600 gallons (80 cubic metres) per hour to a height of 393 feet (120 metres), taking into account both suction and loss of load. It consists of seven revolving wheels mounted on the same shaft and connected in series, so as to be traversed by the same current of water, the pressure increasing from one wheel to another, and each giving a fraction of height equal to the total height divided by the number of wheels. The efficiency of the centrifugal pump and its electric motor is 60 per cent., less by nearly

30 per cent. than that of the plunger-pump and its motor; but the maintenance of the former is insignificant, while for the latter there is the expense of lubricating and repairs, and also that of at least one man. In addition to this, the space occupied by the centrifugal pump is very small, being 8·5 feet (2·6 metres) long, 3 feet (90 centimetres) wide, and 2·6 feet (80 centimetres) high, while no foundations are required: as compared with which the plunger-pump requires a large underground engine-room, and strong foundations. J. W. P.

ELECTRIC PLANT AT THE COKE-OVENS OF THE ORLAU-LAZY MINES, AUSTRIAN SILESIA.

Die elektrische Anlage in der Cokesanstalt des Steinkohlenbergbaues Orlau-Lazy in Oesterr.-Schlesien. *By* ARMIN HARTMANN. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1901, *vol. xlix., pages* 235-240, *with* 5 *illustrations in the text and* 1 *plate.*

At the coke-oven plant at Orlau-Lazy colliery, electric transmission has lately been introduced, and the results obtained are highly satisfactory. The motive power is steam furnished by 10 boilers, each with a heating surface of 1,150 square feet and a pressure above the atmosphere of 147 pounds. The boilers also serve the distillery where sulphate of ammonia and liquid ammonia are produced, and the benzol-factory. The works are spread over so large an area that a high-pressure electric current is required for power, and a low-pressure current for lighting. The reversed-current system has therefore been adopted, with a tension of 330 volts at the central station, for the coke-oven plant, and 3,000 volts at the outlying stations. For the incandescent light, a secondary current of 100 volts is provided.

At the central station, there are three dynamos coupled direct to compound condensing steam-engines, which run at 145 revolutions per minute. The engines have piston valve-gear, and sensitive tangential governors.

The coal is delivered in pieces cubing 4 inches, and is washed and sorted in jigger-screens, and the slate separated. It is then conveyed through an electrically-driven centrifugal pump to three enormous hoppers. The water is here drained off, and the coal carried to an electrically-driven disintegrator, where it is crushed, and passes thence to a storage-tower and the coke-ovens. By means of transmission-gear a 200 horsepower engine placed at a height of 62 feet above the ground drives the jigger-screens, the air-blast for the water, two elevators to carry away the slate, and the centrifugal pump. The disintegrator, an endless belt to convey the coal to it, and the elevator for the washed coke, are driven by another engine of 100 horsepower. The water which runs from the draining hoppers, being charged with coal-dust, is collected in a sump, and the coal which settles at the bottom is raised by a centrifugal pump in the basement, and returned to the main storage.

The coke is discharged from the ovens by a machine driven direct from the dynamos. By means of a cogwheel and rack, the ram is pushed forward at a speed of 22 feet per minute, and carries the coke with it. The machine may also be moved forward, by throwing the lever working the ram out of gear, and bringing another into play which forms the axle of the wheels of the machine.

The gases of the coke-ovens are exhausted by two electrically-driven

exhausters, and burnt under the boilers, after they have been washed, and the tar and ammonia recovered. Two motors of 50 horsepower in the boiler-house drive the feed-water pumps, and the pumps for the condensation-water. There are also two electric motors in the workshops for driving the mechanical tools, and a coke-separator.

A similar electric-transmission-plant is about to be installed at Karwin, but the waste-gases of the coke-ovens will be utilized to drive large gas-engines by direct combustion. E. M. D.

ELECTRICAL PROGRESS IN MINING AND METALLURGY.

Electricity in Mining. *By* GEORGE H. GIBSON. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 307-309, *with* 8 *illustrations in the text.*

Electric machinery was first introduced into the Cripple Creek district in 1888, and it was soon found to be more profitable for the individual mine-owners to rent motors and power from electric-power companies. The power plant of one of these companies is situated at Canyon City, and the current is transmitted 27 miles to Cripple Creek, driving crushing machinery, hoists, air-compressors, pumps, etc. The miner goes to work in an electric car, descends the mine in an electric hoist, drains his mine with an electric pump, works by the electric light, runs drills operated by electric motor-driven air-compressors (in some cases now being replaced by direct electric drills) and fires his shots by electricity. Within an area of 6 square miles, this district contains gold-mines whose production in 1900 amounted to nearly £4,500,000 (22,500,000 dollars).

The Trade-dollar Mining Company, of Silver City, Idaho, has recently erected a larger water-power plant at Swan Falls on the Snake river, from which power is transmitted to their mine 27 miles distant. The generators are operated from a jack-shaft driven by four vertical turbines. The alternators deliver three-phase current at 500 volts, which is stepped up to 22,000 volts for transmission.

The Golden Gate cyanide gold-reduction plant is supplied with electric power from a plant at Provo, Utah, 30 miles distant; the transmission is at 35,000 volts.

Electric power is very extensively used in coal-mines for hauling, hoisting, ventilating, pumping and lighting. The Keeling mine, near Pittsburg, has lately substituted, for rope-haulage, a haulage by electric locomotives. The Berwind-White Company, having a present daily output of 5,000 tons, do all their haulage entirely by electricity. The thing which strikes an English reader most forcibly is the steady manner in which rope-haulage is being superseded by the electric locomotive in American mines.

X. Y. Z.

WATER-SUPPLY AND GOLD-PLACERS OF SONORA, MEXICO.

The Upland Placers of La Cienega, Sonora, Mexico. *By* ROBERT T. HILL. *The Engineering and Mining Journal* [*New York*], 1902, *vol. lxxiii., pages* 132-134, *with* 7 *illustrations in the text.*

In May, 1901, the writer was requested to examine certain auriferous deposits in the vicinity of Cienega, district of Altar, Sonora, Mexico, which, in some respects may be described as a diminutive American Kalgoorlie.

Northwestern Sonora is a dreary desert-country. A few rivers drain the western slopes of the Sierra Madre, and attain considerable volume in their upper waters, but they gradually decrease in copiousness, until most of them sink into the desert-wastes before reaching the Pacific Ocean, except in times of extreme flood.

The writer's duty at Cienega was to make a preliminary report upon the gold-dirt, and to ascertain whether there was any feasible method of recovering it. Thorough samplings readily demonstrated the great richness of the ground, but, the existence of the gold being apparent, the important problem was to ascertain whether there was any manner of applying water to the recovery of this gold, and herein came the application of an interesting study of the question of underground water. The writer believes himself to have been the first to advocate some 12 years ago the principle that in the desert-region of arid America, the underground conditions are favourable for the collection of water in the loose detritus filling the desert-valleys, rather than in the impervious mountain-rocks which crop out around the rims of the deserts and lie beneath them as a floor.

In the vicinity of Cienega, there are three large desert-basins, and each indicates a supply of underground water which, properly conserved and applied, should save much of the gold of the rich placer-deposits. The smallest of these deserts is that in which the village of Sonora itself is situated, and here the most apparent evidence of considerable stores of underground water was manifested by the Cienega itself, from which the village takes its name. This is nothing more nor less than a point in the lowest part of the basin, where the ground-water comes out at the surface. Wells in the village strike this water at a depth of about 8 feet. The water is in considerable quantities, and a small stamp-mill has been run for many years in the village. A low chain of hills separates Cienega from a still larger basin, some 10 miles in cross-section to the northward, and an arroyo leads into this larger basin through the chain of Cienega hills from a still larger basin to the southeast. In the bottom of this arroyo are two wells. One was in constant use to run a small stamp-mill to which ore is brought from the mountains, some 10 miles distant. The other was constructed for the Mina Colorado, 9 miles north of the well and some 300 feet higher in altitude. It has since been abandoned, owing to the exhaustion of the mine.

On the writer's recommendation, this well was deepened from 15 feet, where the water was first encountered, to 57 feet, and two large pumps cannot exhaust it. It is estimated that this well yields about 326 gallons per minute, and the water flows in with increasing quantity with each foot gained in depth. With this water, the company now has an abundant supply to fill ponds for working the ground by the dredge-process, or even for fluming on a small scale. The probabilities are that this water-supply can be largely increased by other wells judiciously located. X. Y. Z.

ELECTRIC COAL-LOADING PLANT.

Nouvel Appareil d'Embarquement des Charbons aux Mines de Dourges. By — PRUDHOMME. *Comptes-rendus mensuels des Réunions de la Société de l'Industrie Minérale*, 1903, *pages* 75-76, *and* 3 *plates.*

The plant was required to discharge railway-wagons carrying 15 tons, at a single stroke, and to load the coal into canal-boats, the difference of level

between the quay and the surface of the water being only 10 feet (3 metres), and all the plant being driven electrically with current generated at a central station, 3 miles (5 kilometres) distant, by the waste gases of the coke-ovens.

The wagon is tipped sideways by a jack, or prop, guided by rollers, the upper end of which jack engages with the corner made by the bottom and one side of the wagon-body. The lower end of the jack has a pivot carrying a grooved pulley; and the movement is effected by a drive-chain, moored to a fixed point, passing round the above-named pulley and also the driving-pulley, a little below ground-level, terminating in a counter-weight for keeping the chain tight, while a cam on the jack, constantly bearing against a guide, keeps the wagon in contact during the operation of tipping. This operation is terminated by the automatic interruption of the current; and the empty wagon returns by its own weight and that of the jack, regulated by a powerful brake, capable of maintaining the loaded wagon, and normally kept applied.

The 15 tons of coal are received on a shoot, fixed at an angle of 37 degrees, with a shutter at its lower end for regulating the fall; and from this shoot the coal is delivered, by a travelling belt of the Lens type, into a fixed hopper, with an horizontal Archimedean screw at the bottom for removing the dust. Communicating with the hopper, and movable in a vertical plane round pivots in its sides, is a spout, terminating below in a beak, or curved end (also provided with a shutter) that turns on a vertical axis. The lower end of the spout is let down by a winch-and-chain into the boat; and the curved end is turned by mechanical means as required.

The boats are made fast to an endless rope, carried by two loose pulleys and driven by a grooved pulley round which it takes two turns, while a clutch permits of stopping the rope or drawing it in one or the other direction. A bridge over the canal affords the opportunity of watching the wagons and the boat, while there are brought together at this point, the levers that give motion to the travelling-belt, the loading-spout, the adjustable beak and the winch for moving the boats.

The pressure of the three-phase current is 5,000 volts, reduced to 240 volts by a transformer; and the two electromotors of 20 horsepower are started without a resistance-coil.

The plant, which can easily load 100 tons per hour, cost £3,200 (80,000 francs), and the cost of loading is less than ½d. (5 centimes) per ton.

J. W. P.

II.—REPORT OF THE CORRESPONDING SOCIETIES' COMMITTEE OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, SOUTHPORT, 1903.*

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The following Corresponding Societies nominated delegates to represent them at the Conferences:—The Institution of Mining Engineers, Prof. Henry Louis; the Midland Counties Institution of Engineers, Prof. Henry Louis; the Midland Institute of Mining, Civil and Mechanical Engineers, Mr. G. B. Walker; the North of England Institute of Mining and Mechanical Engineers, Mr. John Gerrard; and the South Staffordshire and East Worcestershire Institute of Mining Engineers, Prof. Henry Louis.

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First Conference, September 10th, 1903.

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The CHAIRMAN (Mr. W. Whitaker) read the following resolution, which, he said, had been passed by every Section that morning: That, as urged by the President in his address, it is desirable that scientific workers and persons interested in science be so organised that they may exert permanent influence on public opinion, in order more effectively to carry out the third object of this Association, originally laid down by its founders, viz. "To obtain a more general attention to the objects of science and the removal of any disadvantages of a public kind which impede its progress," and that the Council be asked to take steps to promote such organisation.

The motion was then put from the Chair and carried unanimously.

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Second Conference, September 15th, 1903.

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Railway Fares for Members of Scientific Societies.

The SECRETARY read the following letter from Mr. Herbert Stone, F.L.S., F.R.C.I., President of the Birmingham Natural History and Philosophical Society, and Delegate to the meeting:—

With the assistance of my colleague, Mr. Richard Hancock, I have recently been engaged in getting up a petition to the great railway companies, on behalf of the scientific and photographic societies of the Midlands, asking for the same privileges as are enjoyed by anglers, namely, the picnic-rate, or fare-and-a-quarter, to certain specified places upon presentation of the Association ticket at the booking-office. The joint committee formed for the purpose of gaining this end, and of which Mr. Hancock and I are joint secretaries, represents twenty-two societies, with a membership of 1,700. Our petition has met with a

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refusal, after being before the periodical meetings of the managers of the various railway companies. At these meetings all questions affecting railways in general are discussed, and amongst more important matters a petition such as ours would naturally get scant attention, and I doubt if the meeting was put in possession of the arguments for our side as set forth in our letter.

My object is to ask if the British Association can aid us. An application from the Association would at least be considered, whereas the curtness of the replies to our petition shows that the companies consider that we are a negligible quantity.

Of course it would be unreasonable to suppose that the Association would act for a limited body of societies, but I imagine from the support given to the project from those already organised that it would not be difficult to obtain the assistance of the whole of the societies of the same nature in Great Britain. In this work I should be pleased to take my share.

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COMMITTEES APPOINTED BY THE GENERAL COMMITTEE AT THE SOUTHPORT MEETING IN SEPTEMBER, 1903.

I.—NOT RECEIVING GRANTS OF MONEY.

Subject for Investigation or Purpose.	Members of the Committee.
The rate of increase of underground temperature downwards in various localities of dry land and under water.	*Chairman and Secretary.*—Prof. J. D. Everett. Lord Kelvin, Sir Archibald Geikie, Prof. Edward Hull, Dr. C. Le Neve Foster, Prof. A. S. Herschel, Prof. G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. Edward Wethered, Mr. A. Strahan, Prof. Michie Smith, Prof. H. L. Callendar and Mr. B. H. Brough.
The consideration of the teaching of elementary mechanics, and the improvement which might be effected in such teaching	*Chairman*—Prof. Horace Lamb. *Secretary*—Prof. J. Perry. Mr. C. Vernon Boys, Profs. Chrystal, Ewing, G. A. Gibson, and Greenhill, Principal Griffiths, Prof. Henrici, Dr. E. W. Hobson, Mr. C. S. Jackson, Sir Oliver Lodge, Profs. Love, Minchin and Schuster, and Mr. A. W. Siddons.
The nature of alloys.	*Chairman and Secretary.*—Mr. F. H. Neville. Mr. C. T. Heycock and Principal E. H. Griffiths.
The collection, preservation, and systematic registration of photographs of geological interest.	*Chairman.*—Prof. J. Geikie. *Secretary.*—Prof. W. W. Watts. Prof. T. G. Bonney, Dr. T. Anderson, Profs. E. J. Garwood and S. H. Reynolds, and Messrs. A. S. Reid, W. Gray, H. B. Woodward, R. Kidston, J. J. H. Teall, J. G. Goodchild, H. Coates, C. V. Crook, G. Bingley, R. Welch, A. K. Coomáraswámy and W. J. Harrison.
To promote the registration of type-specimens of fossils in the British Isles.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Dr. A. Smith Woodward. Rev. G. F. Whidborne, Mr. R. Kidston, Prof. H. G. Seeley, Mr. H. Woods and Rev. J. F. Blake.
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2.—Receiving Grants of Money.

Subject for Investigation or Purpose.	Members of the Committee.	Grants. £ s. d.
Seismological observations	*Chairman.*—Prof. J. W. Judd. *Secretary.*—Mr. J. Milne. Lord Kelvin, Prof. T. G. Bonney, Mr. C. V. Boys, Prof. G. H. Darwin, Mr. Horace Darwin, Major L. Darwin, Prof. J. A. Ewing, Dr. R. T. Glazebrook, Prof. C. G. Knott, Prof. R. Meldola, Mr. R. D. Oldham, Prof. J. Perry, Mr. W. E. Plummer, Prof. J. H. Poynting, Mr. Clement Reid, Mr. Nelson Richardson and Prof. H. H. Turner.	40 0 0
To co-operate with the Committee of the Falmouth Observatory in their magnetic observations.	*Chairman.*—Sir W. H. Preece. *Secretary.*—Dr. R. T. Glazebrook. Prof. W. G. Adams, Captain Creak, Mr. W. F. Fox, Prof. A. Schuster and Sir A. W. Rücker.	60 0 0
To investigate the erratic blocks of the British Isles, and to take measures for their preservation.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Prof. P. F. Kendall. Prof. T. G. Bonney, Mr. C. E. De Rance, Prof. W. J. Sollas, Mr. R. H. Tiddeman, Rev. S. N. Harrison, Mr. J. Horne, Mr. F. M. Burton, Mr. J. Lomas, Mr. A. R. Dwerryhouse, Mr. J. W. Stather, Mr. W. T. Tucker and Mr. F. W. Harmer.	10 0 0 and balance in hand.
The movements of underground waters of north-west Yorkshire.	*Chairman.*—Prof. W. W. Watts. *Secretary.*—Mr. A. R. Dwerryhouse. Prof. A. Smithells, Rev. E. Jones, Mr. Walter Morrison, Mr. G. Bray, Rev. W. Lower Carter, Mr. T. Fairley, Mr. P. F. Kendall and Mr. J. E. Marr.	Balance in hand.
To study life-zones in the British Carboniferous rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Dr. Wheelton Hind. Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Prof. E. J. Garwood, Dr. G. J Hinde, Prof. P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Prof. G. A. Lebour, Mr. B. N. Peach, Mr. J. T. Stobbs, Mr. A. Strahan and Dr. H. Woodward.	35 0 0
To investigate the resistance of road vehicles to traction.	*Chairman*—Sir J. I. Thornycroft. *Secretary.*—Prof. H. S. Hele-Shaw. Mr. T. Aitken, Mr. T. C. Aveling, Prof. T. Hudson Beare, Mr. W. W. Beaumont, Mr. J. Brown, Col. R. E. Crompton, Mr. B. J. Diplock, Mr. A. Mallock, Prof. J. Perry, Sir D. Salomons, Mr. A. R. Sennett, Mr. E. Shrapnell Smith and Prof. W. C. Unwin.	90 0 0
Corresponding Societies Committee for the preparation of their report.	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. F. W. Rudler. Sir John Evans, Rev. J. O. Bevan, Dr. H. T. Brown, Dr. Vaughan Cornish, Mr. T. V. Holmes, Mr. J. Hopkinson, Prof. R. Meldola, Dr. H. R. Mill, Mr. C. H. Read, Rev. T. R. R. Stebbing, Prof. W. W. Watts and the General Officers.	20 0 0
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THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1903–1904.

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Andersonian Naturalists' Society, 1885	Andersonian Nat. Soc.	204, George Street, Glasgow. R. Barnett Johnstone and T. Nisbet.	245	None	2s. 6d.	Annals, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C. ..	J. Langfield Ward, Royal Literary and Scientific Institution, Bath.	100	5s.	10s.	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, M.R.I.A.	243	None	£1 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863..	Belfast Nat. F. C. ..	Museum, College Square. R. Patterson and N. H. Foster.	350	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831..	Berwicksh. Nat. Club ..	Rev. J. J. M. L. Aiken, B.D., Manse of Ayton, Berwickshire.	400	None	10s.	History of the Berwickshire Naturalists' Club, annually.
Birmingham and Midland Institute Scientific Society, 1859	Birm. & Mid. Inst. Sci. Soc.	Alfred Cresswell, Birmingham and Midland Institute, Paradise Street, Birmingham.	140	None	£1 6s.	Records of Meteorological Observations, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Norwich Union Chambers, Congreve Street, Birmingham. W. P. Marshall and W. B. Grove, M.A.	172	None	£1 1s.	Proceedings, annually.
Brighton and Hove Natural History and Philosophical Society, 1854	Brighton N. H. Phil. Soc.	J. C. Clark, 9, Marlborough Place, Brighton.	170	10s.	10s.	Report, annually.
Bristol Naturalists' Society, 1862 ..	Bristol Nat. Soc. ..	S. H. Reynolds, M.A., University College, Bristol.	152	5s.	10s.	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, F.I.C., 5, Chapel Street, Peterhead.	170	5s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc..	B. L. Oswell, 5, Balmoral Road, Burton-on-Trent.	210	None	5s.	Annual Report. Transactions, occasionally.
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C..	H. E. Forrest, 37, Castle Street, Shrewsbury.	168	5s.	5s.	Transactions and Record of Rare Facts, annually.
Cardiff Naturalists' Society, 1867 ..	Cardiff Nat. Soc. ..	Wm. Sheen, M.Sc., 2, St. Andrew's Crescent, Cardiff.	470	None	15s.	Transactions, annually.
Chester Society of Natural Science, Literature and Art, 1871	Chester Soc. Nat. Sci..	Grosvenor Museum, Chester. G. P. Milln and W. F. J. Shepheard.	977	None	5s.	Report and Proceedings, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc. .	The Museum, Public Buildings, Penzance. John B. Cornish.	96	None	£1 1s.	Report and Transactions, annually.
Croydon Natural History and Scientific Society, 1870	Croydon M. N. H. C. .	Public Hall, Croydon. G. W. Moore.	220	None	10s.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C..	Dr. H. C. March, Portesham, Dorchester.	333	10s.	10s.	Proceedings, annually.
Dublin Naturalists' Field Club, 1885..	Dublin N. F. C.	G. H. Pethybridge, Ph.D., and J. de W. Hulsh, Royal College of Science, Dublin.	150	5s. Associates, 2s. 6d.	5s. Associates, 2s. 6d.	*Irish Naturalist*, monthly. Report, annually.
East Kent Scientific and Natural History Society, 1857	E. Kent S. N. H. Soc..	A. Lander, The Medical Hall, Canterbury.	102	None	10s.	Transactions, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1903-1904.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Eastbourne Natural History Society, 1867	Eastbourne N.H. Soc...	Dr. H. Habgood, Stafford House, Upperton Road, Eastbourne.	100	2s. 6d.	7s. 6d.	Transactions, annually.
Edinburgh Geological Society, 1834..	Edinb. Geol. Soc. ..	India Buildings, Edinburgh, James Currie, M.A., F.R.S.E.	250	10s. 6d.	12s. 6d.	Transactions, annually.
Elgin and Morayshire Literary and Scientific Association	Elgin Lit. Sci. Assoc...	R. B. Gordon, Elgin	98	None	5s.	Transactions, occasionally.
Essex Field Club, 1880	Essex F. C.	William Cole, Springfield, Epping New Road, Buckhurst Hill, Essex.	300	None	15s.	*Essex Naturalist*, quarterly; *Special Memoirs, &c.*, occasionally.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc. ..	J. Barclay Murdoch, Capelrig, Newton-Mearns, Glasgow.	250	None	10s.	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc. ..	R. Brown, M.D., Belhaven House, Pollokshields, Glasgow	270	None	7s. 6d.	Transactions and Proceedings, annually.
Glasgow, Royal Philosophical Society of, 1802	Glasgow R. Phil. Soc...	Dr. Freeland Fergus, 207, Bath Street, Glasgow.	1,090	£1 1s.	£1 1s.	Proceedings, annually.
Halifax Scientific Society, 1874 .	Halifax S. S. ..	Literary and Philosophical Society's Rooms, Harrison Road. F. Barker.	135	None	2s. 6d.	*Halifax Naturalist*, every two months.
Hampshire Field Club and Archæological Society, 1885	Hants. F. C.	W. Dale, F.G.S., 5, Sussex Place, Southampton.	250	None	7s. 6d.	Proceedings, annually.
Haslemere Microscope and Natural History Society	Haslemere Mic. N. H. Soc.	Rev. G. B. Stallworthy, The Manse, Hindhead, Surrey.	400	None	Minimum, 2s.	Report, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts. N. H. Soc. ..	A. E. Gibbs, F.L.S., St. Albans, and T. E. Lones, M.A., Watford.	200	10s.	10s.	Transactions, occasionally.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C. ..	G. E. Frisby 1, Claudeboye Villas, Fengates' Road, Redhill.	108	10s. and 5s.	10s. and 5s.	Proceedings, every two or three years.
Hull Geological Society, 1887	Hull Geol. Soc.	J. W. Stather, F.G.S., 16, Louis Street, Hull.	75	None	5s.	Transactions, annually.
Hull Scientific and Field Naturalists' Club, 1886	Hull Sci. F. N. C. ..	T. Sheppard, F.G.S., The Museum, Hull.	180	None	5s.	Transactions, annually.
Institution of Mining Engineers ..	Inst. Min. Eng. ..	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne.	2,600	None	None	Transactions, monthly.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc. ..	E. G. Critchley, 29, High Street, Inverness.	190	None	5s.	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland ..	J. Pim, W. Lawson and C. H. Oldham, 35, Molesworth Street, Dublin.	100	None	£1.	Journal, annually.
Leeds Geological Association, 1873 ..	Leeds Geol. Assoc. ..	Philosophical Hall, Leeds. Walter Parsons.	83	None	5s.	Transactions, occasionally.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	W. M. Rankin, B.Sc., Cockburn Higher Grade School, Leeds.	90	None	6s.	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	Corporation Museum. Herbert Ellis.	333 Members & Associates.	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, half-yearly.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1903-1904.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Liverpool Engineering Society, 1875	Liverpool E. Soc.	R. C. F. Annett, 4, Buckingham Avenue, Sefton Park, Liverpool.	515	None	Resident, £1 1s.; Non-res. and Students, 10s. 6d.	Transactions and Report, annually.
Liverpool Geographical Society, 1891	Liverpool Geog. Soc.	Capt. E. C. Dubois Phillips, R.N., 14, Hargreave's Buildings, Liverpool.	700	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions and Report, annually.
Liverpool Geological Society, 1858	Liverpool Geol. Soc.	Royal Institution. W. A. Whitehouse.	63	None	£1 1s.	Proceedings, annually.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	T. E. Acheson, Lloyd's Bank, Ramsey, Isle of Man.	135	2s. 6d.	7s. 6d. and 5s.	*Yn Lioar Manninagh*, biennially.
Manchester Geographical Society, 1884	Manch. Geog. Soc.	Eli Sowerbutts, F.R.G.S., 16, St. Mary's Parsonage, Manchester.	800	None	Members, £1 1s.; Associates, 10s. 6d.	Journal, quarterly; *Geography*, monthly.
Manchester Geological and Mining Society, 1838	Manch. Geol. Min. Soc.	5, John Dalton Street, Manchester. W. Saint and J. Tonge, jun.	240	None	£1.	Transactions, monthly.
Manchester Microscopical Society, 1880	Manch. Mic. Soc.	E. C. Stump, 16, Herbert Street, Moss Side, and Charles Knight, 193, Oxford Street, Manchester.	185	5s.	6s.	Transactions and Report, annually.
Manchester Statistical Society, 1833	Manch. Stat. Soc.	Theodore Gregory, 32, York Street, Manchester.	216	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick.	250	1s. 6d.	3s. and 5s.	Report, annually.
Midland Counties Institution of Engineers, 1871	Mid. Count. Inst.	G. Alfred Lewis, Albert Street, Derby.	380	£1 1s.	Members £1 11s. 6d.; Associates and Students, £1	*Transactions of the Institution of Mining Engineers*, monthly.
Midland Institute of Mining, Civil and Mechanical Engineers, 1869	Midland Inst. Eng.	T. W. H. Mitchell, Mining Offices, Regent Street, Barnsley.	300	None	£1 10s.	*Transactions of the Institution of Mining Engineers*, monthly.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, St. Helen's Square, Norwich.	256	None	5s.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne.	1,300	None	£1 5s. and £2 2s.	*Transactions of the Institution of Mining Engineers*, monthly.
North Staffordshire Field Club	N. Staff. F. C.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.; W. Wells Bladen, Stone, Staffs.	461	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	Northants. N. H. Soc.	H. N. Dixon, M.A., 23, East Park Parade, Northampton.	190	None	10s.	Journal, quarterly.
Northumberland, Durham, and Newcastle-upon-Tyne, Natural History Society of	Northumb. N. H. Soc.	Hancock Museum, Newcastle-upon-Tyne. Prof. M. C. Potter, M.A., and N. H. Martin, F.L.S.	450	None	£1 1s.	Transactions, annually.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Prof. J. W. Carr, M.A., University College, Nottingham.	188	2s. 6d.	5s.	Report, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1903-1904.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3, County Place, Paisley.	500	5s.	7s. 6d.	Report, annually; Meteorological Obs., occasionally.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	380	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, M.Sc., 105, Freehold Street, Rochdale.	245	None	6s.	Transactions, biennially.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Linden House, Rochester.	180	None	5s.	*Rochester Naturalist*, quarterly.
Somersetshire Archæological and Natural History Society, 1849	Som'setsh. A.N.H. Soc.	The Castle, Taunton. Lt.-Col. J. R. Bramble, Rev. F. W. Weaver and C. Tite.	612	10s. 6d.	10s. 6d.	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	G. M. Clark, South African Museum, Cape Town.	207	None	£2	Transactions, occasionally.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union .. .	George Abbott, M.R.C.S., 33, Upper Grosvenor Road, Tunbridge Wells.	40 Societies	None	Minimum 5s.	*South-Eastern Naturalist*, annually.
South Staffordshire and East Worcestershire Institute of Mining Engineers, 1867	S. Staff. Inst. Eng. .	Alexander Smith, M.Inst.C.E., 3, Newhall Street, Birmingham.	178	£1 1s. and 10s. 6d.	£1 11s. 6d. and £1 1s.	*Transactions of the Institution of Mining Engineers*, monthly.
Toronto, Astronomical Society of, 1884	Toronto Astr. Soc. .	Canadian Institute Building. J. R. Collins.	125	None	2 dollars	Transactions, annually.
Tyneside Geographical Society, 1887 ..	Tyneside Geogr Soc. ..	Geographical Institute, Barras Bridge, Newcastle-upon-Tyne. Herbert Shaw, B.A., F.R.G.S.	1,200	None	10s. and 5s.	Journal, annually.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C. ..	Museum, Warwick. C. West, Cross Cheaping, Coventry.	99	2s. 6d.	5s.	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore.	240	10s.	10s.	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, M.A., F.G.S., Hopton, Mirfield.	185	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	The Museum, Hull. T. Sheppard, F.G.S.	400 and 2,590 Associates	None	10s. 6d.	Transactions, annually; *The Naturalist*, monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc. ..	Museum, York. Dr. Tempest Anderson and C. E. Elmhirst.	420	None	£2	Report, annually.

CATALOGUE OF THE MORE IMPORTANT PAPERS, AND ESPECIALLY THOSE REFERRING TO LOCAL SCIENTIFIC INVESTIGATIONS, PUBLISHED BY THE CORRESPONDING SOCIETIES DURING THE YEAR ENDING MAY 31ST, 1903.*

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

BROWN, M. WALTON. "Barometer, Thermometer, &c., Readings for the Year, 1901." *Trans. Inst. Min. Eng.*, vol. xxiii., pages 763-772, 1903.

DICKINSON, JOSEPH. "Finding Mineral Veins by Electricity." *Trans. Manch. Geol. Soc.*, vol. xxviii., pages 126-130, 1903.

FOURCADE, H. G. "On a Stereoscopic Method of Photographic Surveying." *Trans. S. African Phil. Soc.*, vol. xiv., pages 28-35, 1903.

GRUBB, SIR HOWARD, and HENRY DAVIS (Mid. Count. Inst. Eng.). "The Grubb Sight for Surveying Instruments." *Trans. Inst. Min. Eng.*, vol. xxii., pages 118-125, 1902.

GURNEY, PRINCIPAL H. P. (N. Eng. Inst.). "The Crumlin Meteorite." *Trans. Inst. Min. Eng.*, vol. xxiv., pages 274-275, 1903.

SCOTT, DUNBAR D. "Mine-surveying Instruments." *Trans. Inst. Min. Eng.*, vol. xxiii., pages 575-620, 1902.

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Section B.—CHEMISTRY.

ACKROYD, WM. "The Presence of Salt in Fresh Waters." *Halifax Naturalist*, vol. viii., pages 11-14, 1903.

BEDSON, DR. P. PHILLIPS (N. Eng. Inst.). "The Gases enclosed in Coal and Coal-dust." *Trans. Inst. Min. Eng.*, vol. xxiv., pages 27-40, 1902.

BROOCKMANN, DR., translated by Prof. H. Louis (N. Eng. Inst.). "The Gases enclosed in Coal." *Trans. Inst. Min. Eng.*, vol. xxiv., pages 18-26, 1902.

DICKSON, HAMILTON C. "Crucible Assaying of Gold-ores." *Trans. Inst. Min. Eng.*, vol. xxii., pages 673-690, 1903.

GOODWIN, W. L. "The Mining, Concentration, and Analysis of Corundum in Ontario, Canada." *Trans. Inst. Min. Eng.*, vol. xxiii., pages 446-455, 1902.

HOSKOLD, C. A. L. "Deposits of Hydroborate of Lime: its Exploitation and Refination." *Trans. Inst. Min. Eng.*, vol. xxiii., pages 456-471, 1902.

LISHMAN, G. P. "The Analytical Valuation of Gas Coals." *Trans. Inst. Min. Eng.*, vol. xxiii., pages 567-574, 1902.

MUIR, J. J. "Treatment of Low-grade Copper Ores in Australia." *Trans. Inst. Min. Eng.*, vol. xxiii., pages 517-524, 1902.

MUSPRATT, MAX. "Some Aspects of Chemical Engineering." *Trans. Liverpool E. Soc.*, vol. xxiii., pages 122-131, 1902.

PETERS, DR. E. D. (N. Eng. Inst.). "Treatment of Low-grade Copper Ores." *Trans. Inst. Min. Eng.*, vol. xxiv., pages 315-321, 1903.

PLOWRIGHT, DR. C. B. "On the Tinctorial Properties of our British Dye Plants." *Trans. Norf. Norw. Nat. Soc.*, vol. vii., pages 386-394, 1902.

STEWART, JAMES (N. Eng. Inst.). "The Valuation of Gas Coals." *Trans. Inst. Min. Eng.*, vol. xxiv., pages 307-310, 1903.

THOMPSON, BEEBY. "How to interpret a Water Analysis," *Journal Northants N. H. Soc.*, vol. xi., pages 161-168, 1902.

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* Titles of Papers on other Subjects than Mining or Mechanical Engineering have not been reprinted.

Section C.—GEOLOGY.

ACKROYD, WILLIAM. "On the Circulation of Salt and its Bearing on Geological Problems, more particularly on that of the Geological Age of the Earth." *Proc. Yorks. Geol. Poly. Soc.*, vol. xiv., pages 401-421, 1902.

BARNES, J. "On a Metamorphosed Limestone at Peak Forest. *Trans. Manch. Geol. Soc.*, vol. xxvii., pages 317-320, 1902.

— "On a Change in the Mineral Deposit in a Stream that passes through the Yoredale Shales near Mam Tor." *Trans. Manch. Geol. Soc.*, vol. xxvii., pages 326-328, 1902.

— "Further Observations on the Change brought about by the Intrusion of Igneous Matter into the Carboniferous Limestone at Peak Forest." *Trans. Manch. Geol. Soc.*, vol. xxvii., pages 366-369, 1902.

— "On a Calcareous Sandstone from Bamberg, Bavaria, Germany." *Trans. Manch. Geol. Soc.*, vol. xxviii., pages 102-105, 1903.

BARROWMAN, JAMES (Mining Inst. Scot.). "Slips in a Sandbank." *Trans. Inst. Min. Eng.*, vol. xxiii., page 154, 1902.

BOWLER, LOUIS P. "Notes on the Gold Coast of West Africa." *Trans. Inst. Min. Eng.*, vol. xxiv., pages 413-414, 1903.

CADELL, HENRY M. "Note on the Buried River Channel of the Almond." *Trans. Edinb. Geol. Soc.*, vol. viii., pages 194-196, 1903.

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EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname; or, in the case of the name of any Firm, Association or Institution, the full name of such Firm, etc.

Discussions are printed in *italics*.

The following contractions are used:—

M.—Midland Institute of Mining, Civil and Mechanical Engineers.

M.C.—The Midland Counties Institution of Engineers.

S.—Mining Institute of Scotland.

N.E.—The North of England Institute of Mining and Mechanical Engineers.

N.S.—North Staffordshire Institute of Mining and Mechanical Engineers.

S.S.—South Staffordshire and East Worcestershire Institute of Mining Engineers.

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